Coulomb excitation of neutron rich odd-A Cu isotopes

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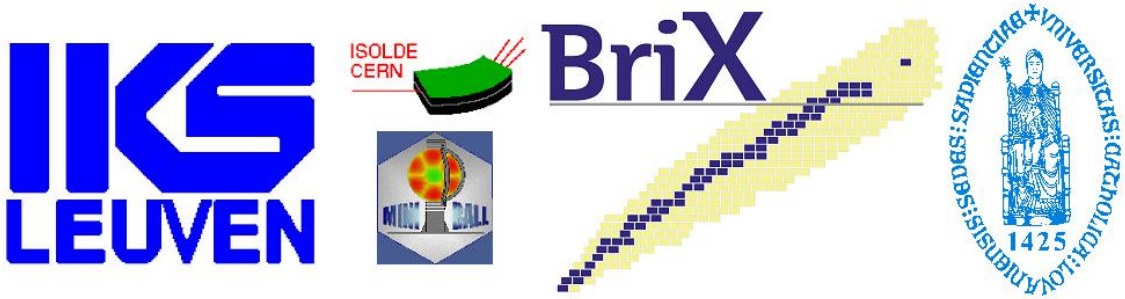
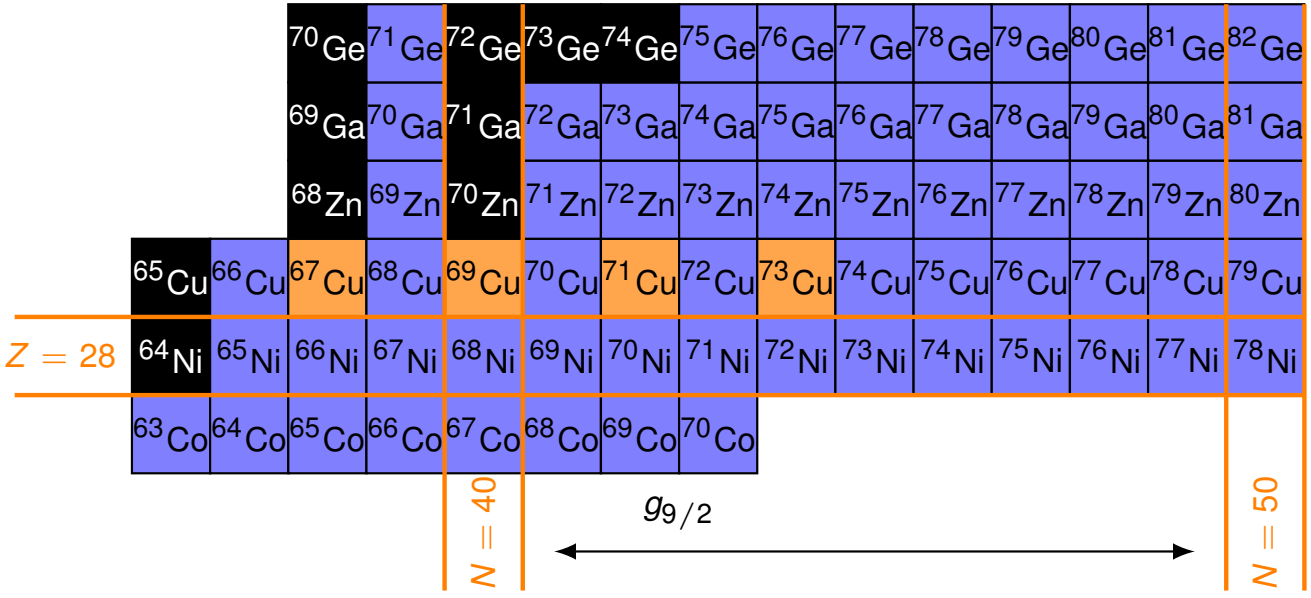
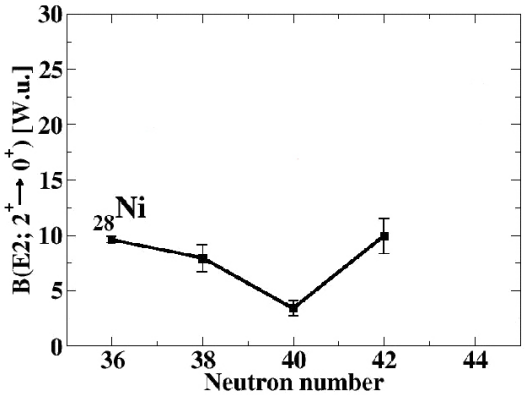
BRIX Workshop 2008

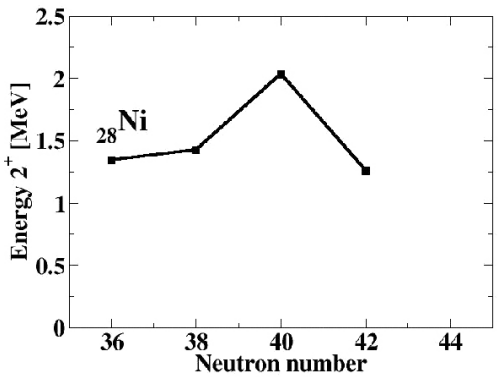


Outline

Outline







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- Evolution of E_{2^+}
- N=40 subshell closure is suggested

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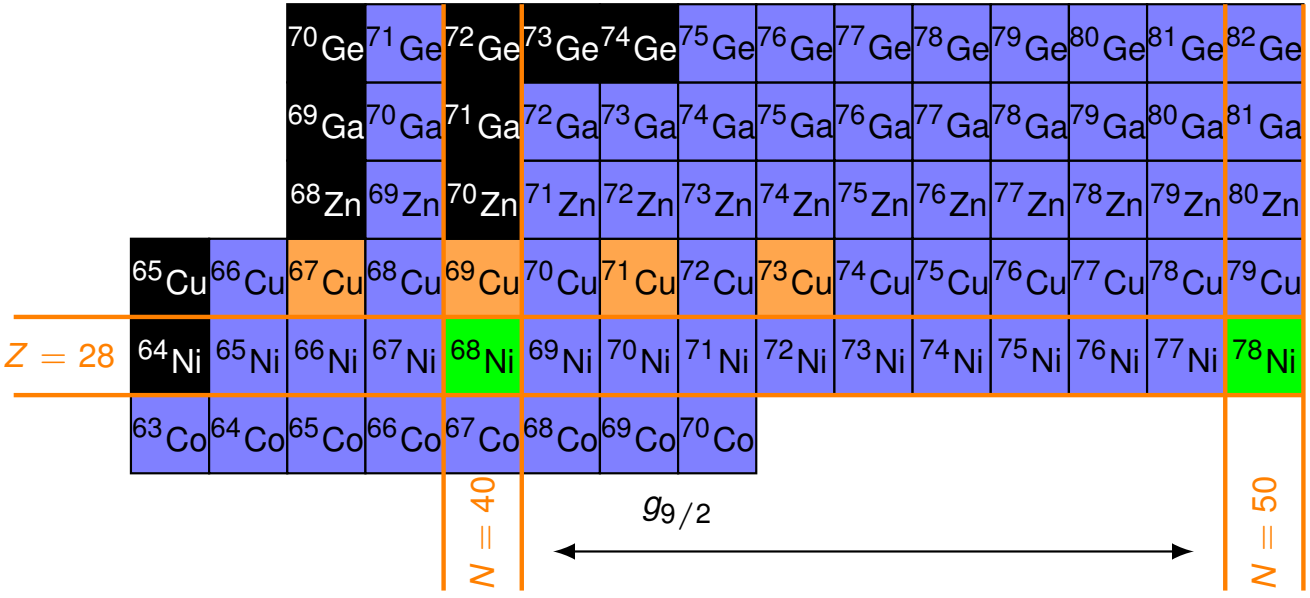

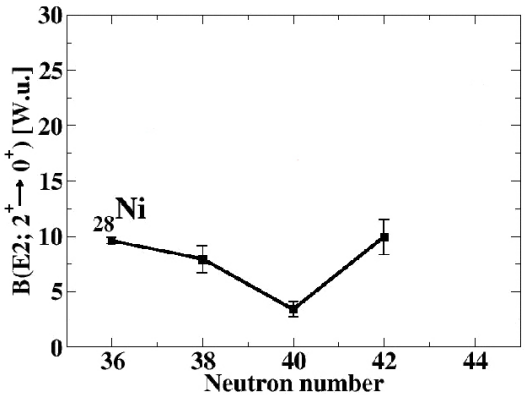

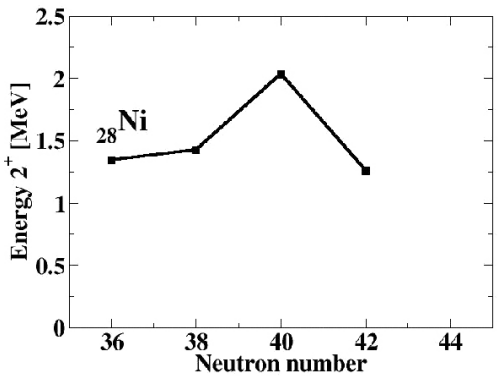

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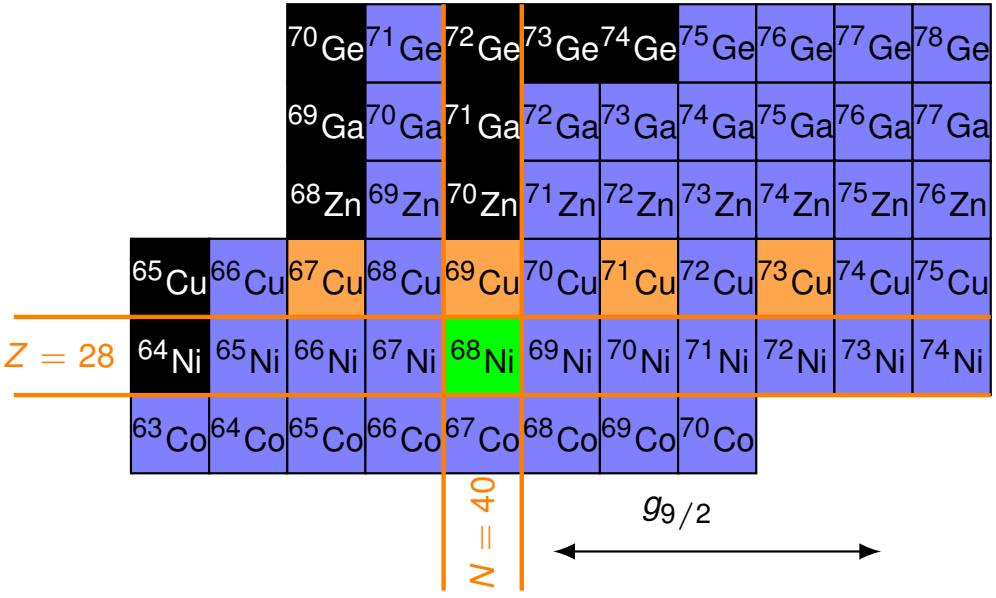

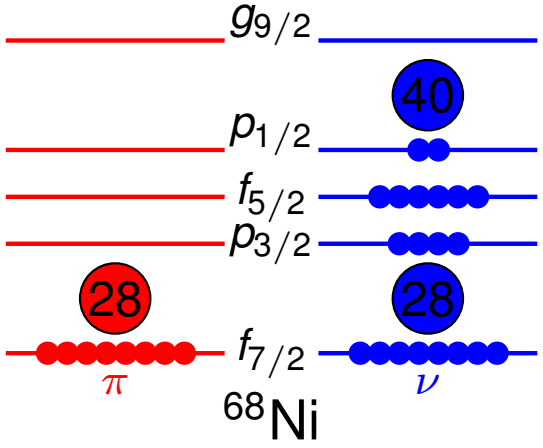

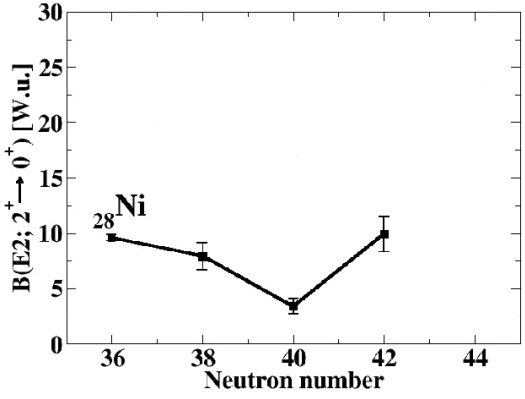

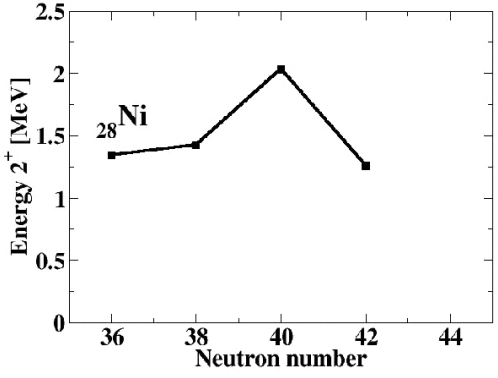

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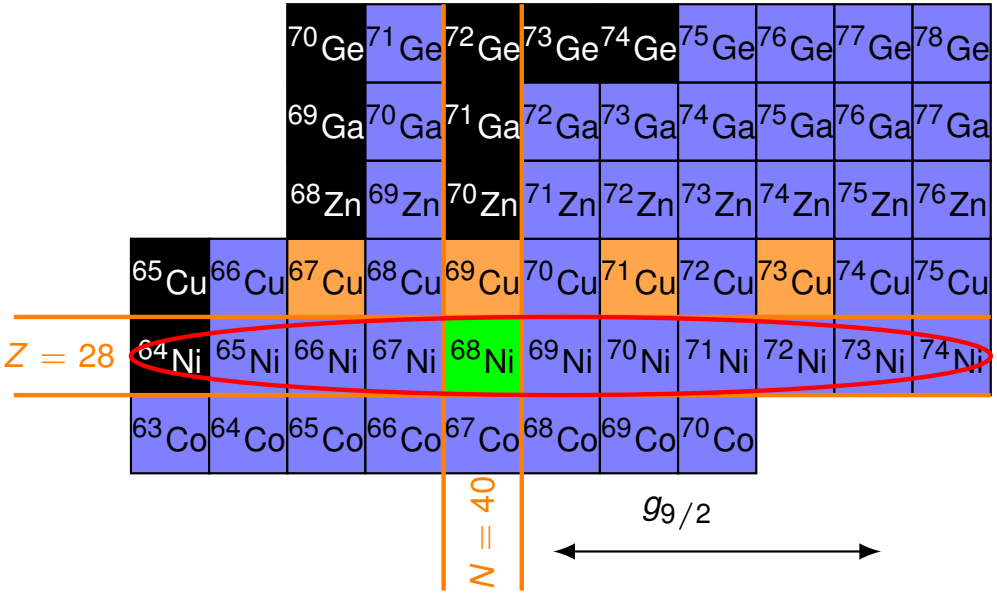

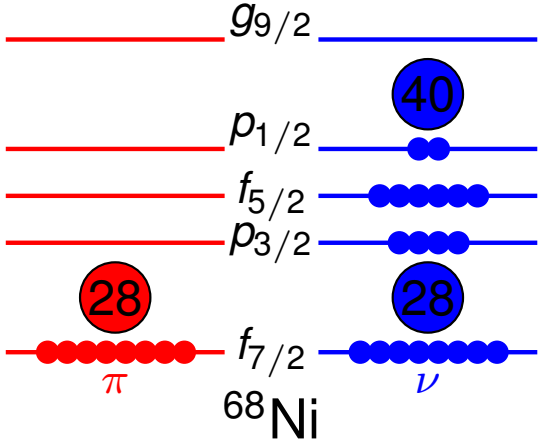

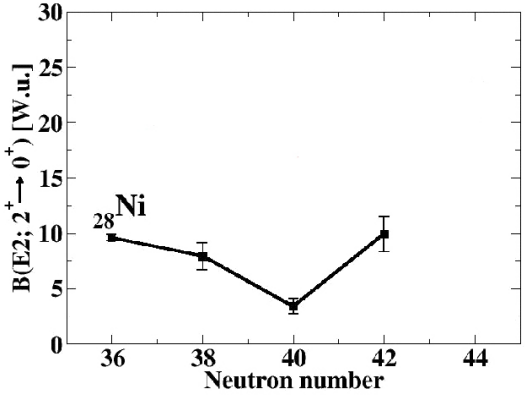

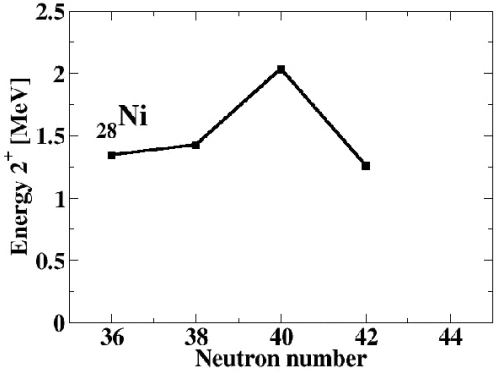

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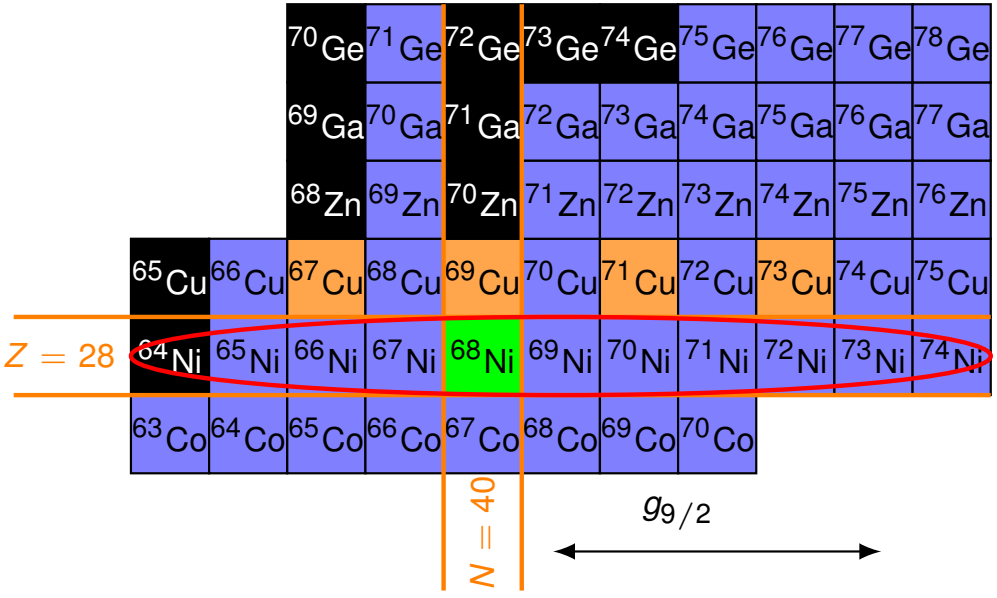

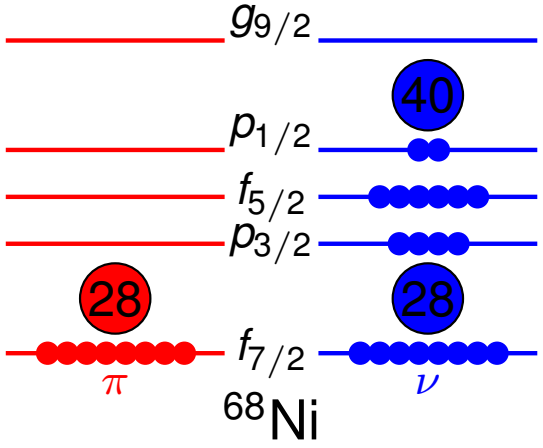

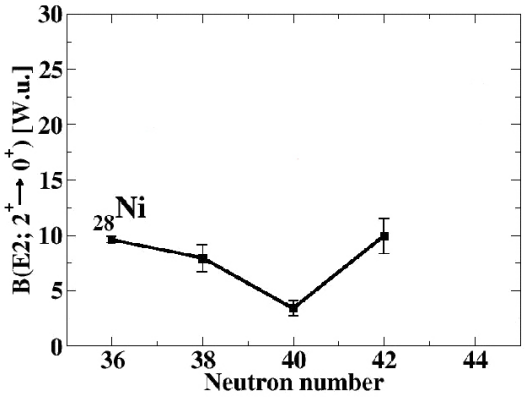

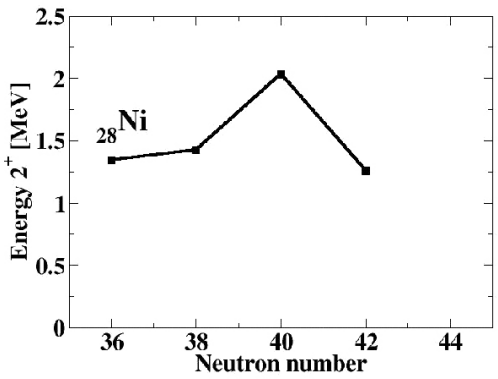

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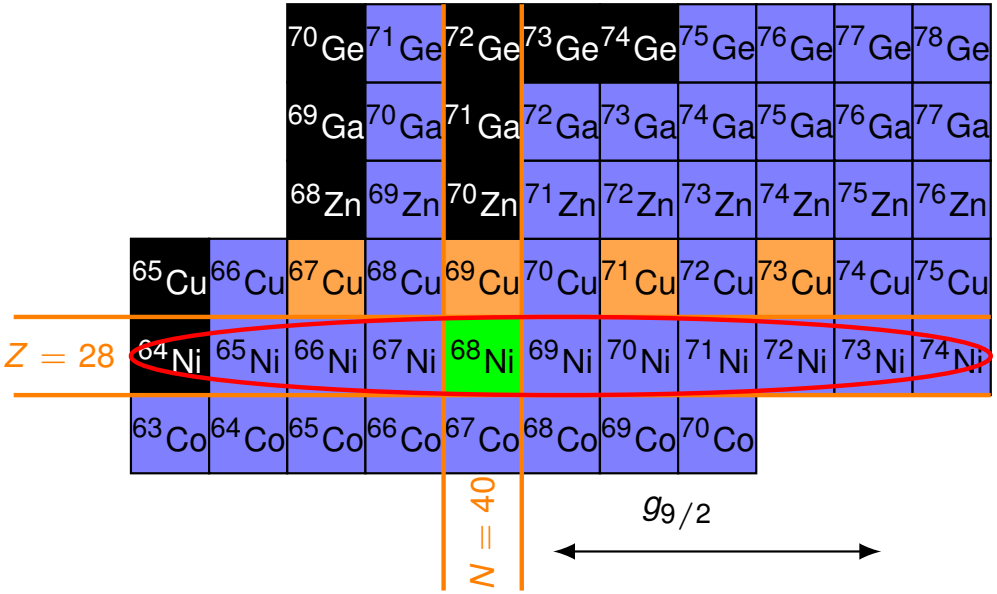

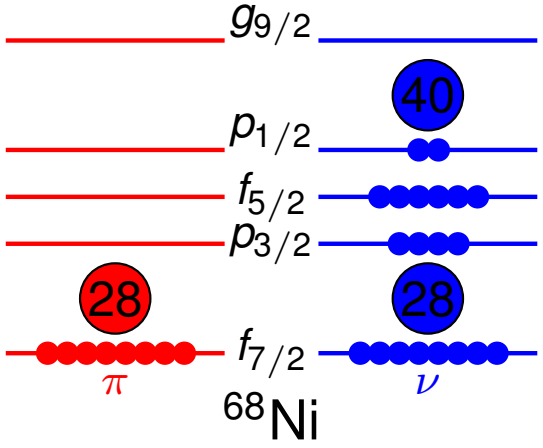

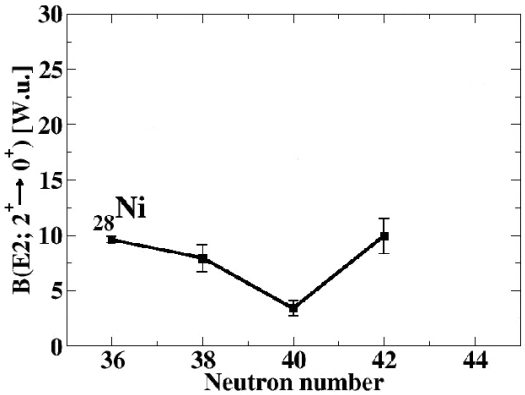

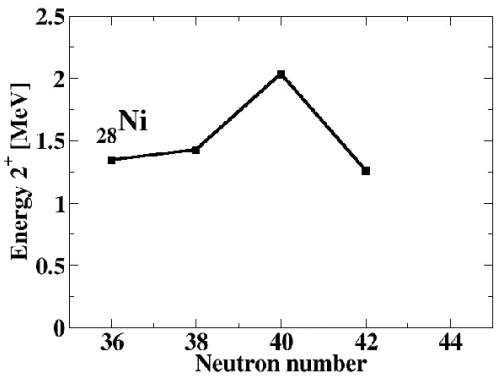

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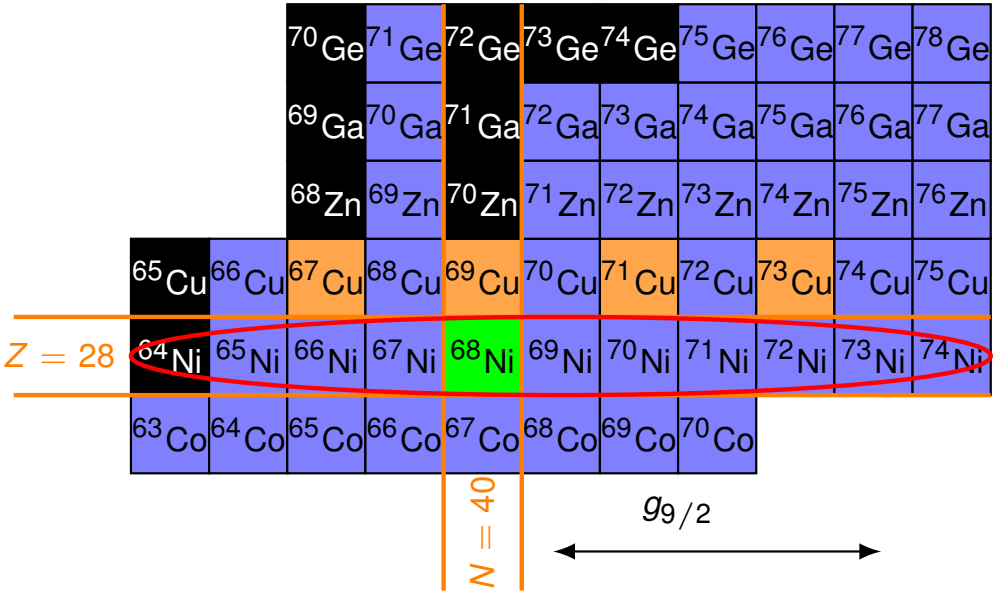

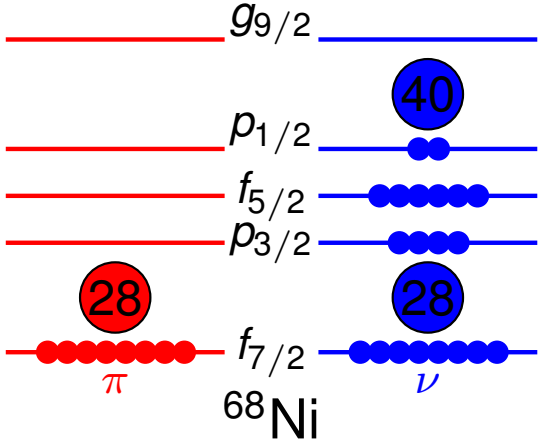

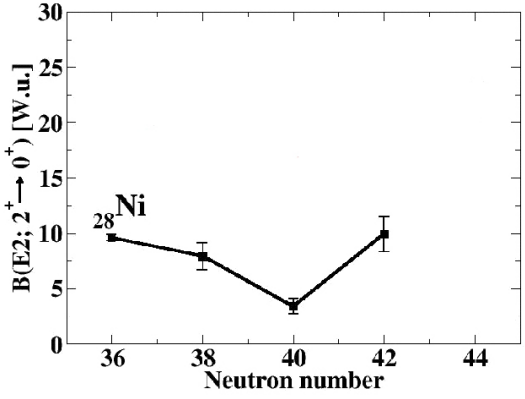

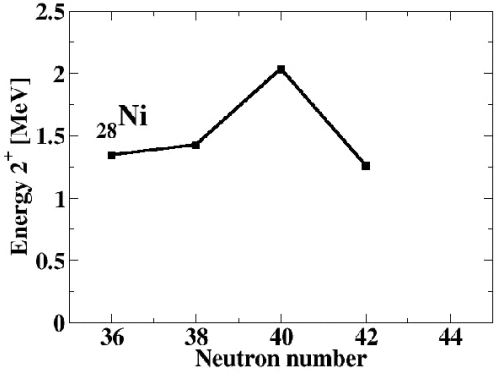

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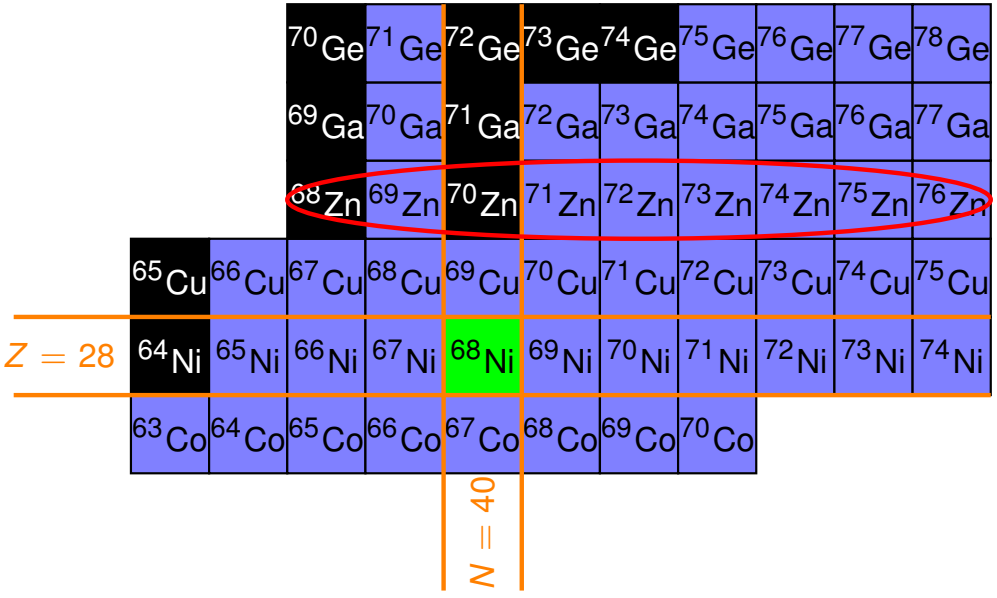
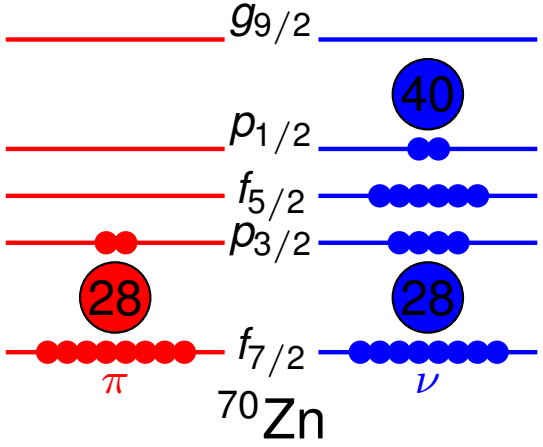
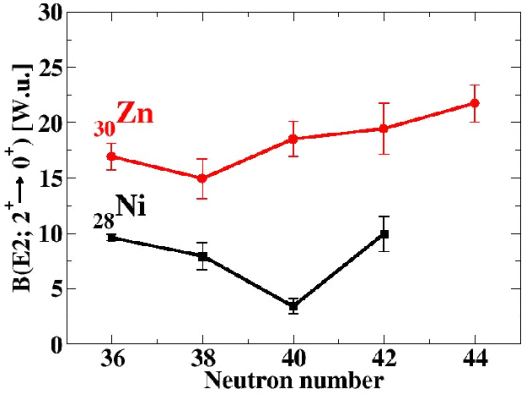
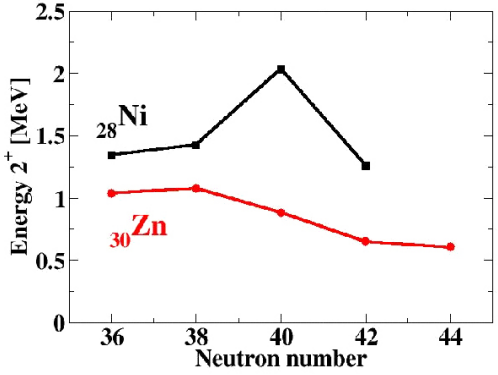


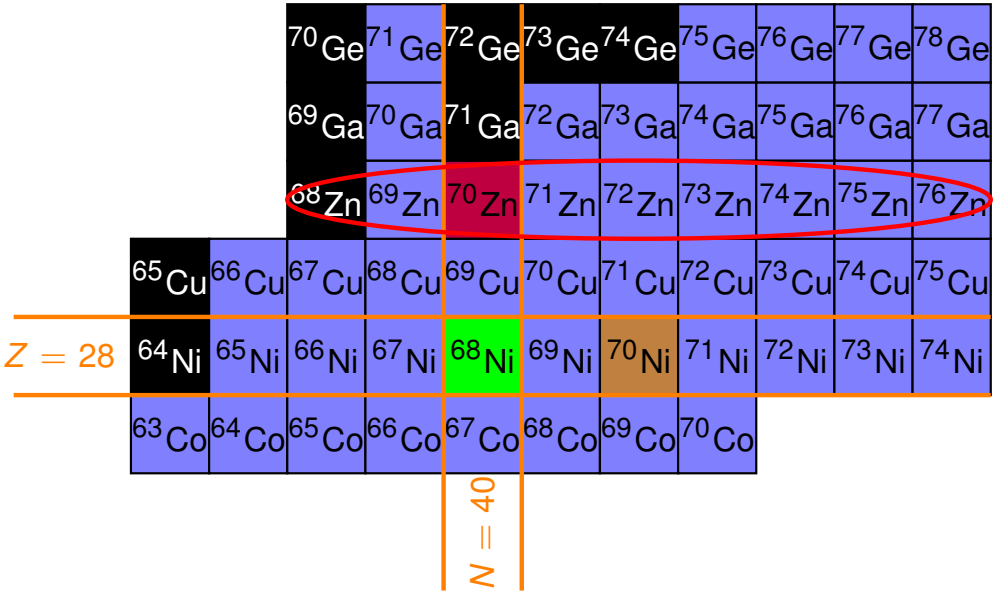


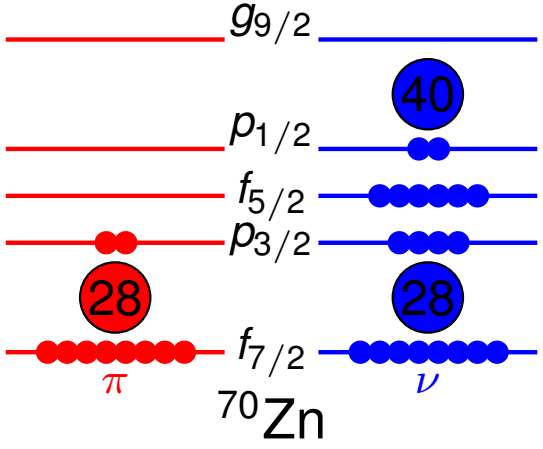


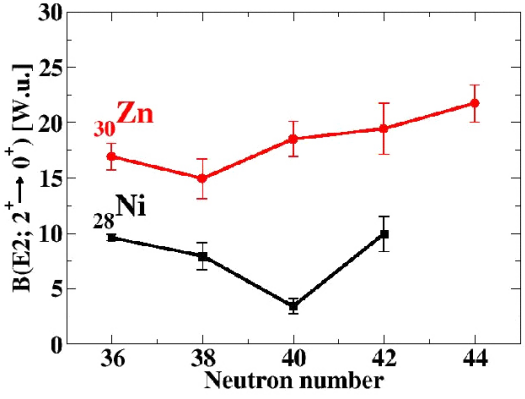


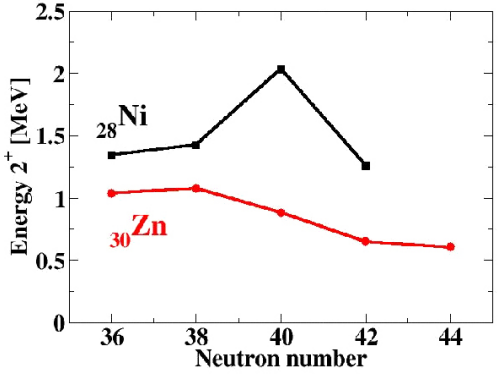
^{70}Zn and ^{70}Ni show large collectivity

[Kenn, 2002], [Perru, 2006]









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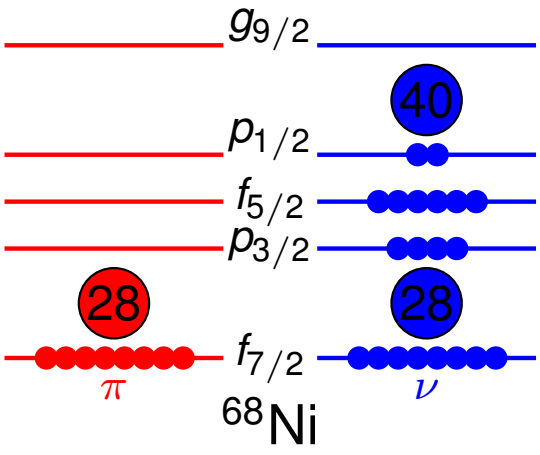
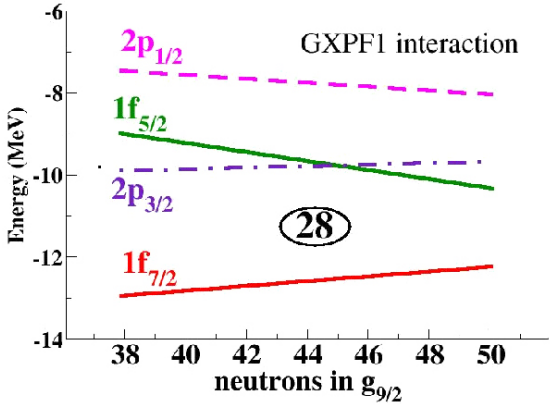
Nuclear structure near the $N = 40$ subshell closure



Increased collectivity beyond $N = 40$

- Interaction between $\nu 1g_{9/2}$ and πfp-shell cause lowering of $1\pi f_{5/2}$ and raising of $1\pi f_{7/2}$
- $1\pi f_{5/2} - 1\pi f_{7/2}$ reduces and causes quenching of $Z = 28$-gap



[Otsuka, 2005]

Aim

Usage of the neutron rich Cu isotopes (Ni $\oplus$ π) to investigate predicted single-particle state effects

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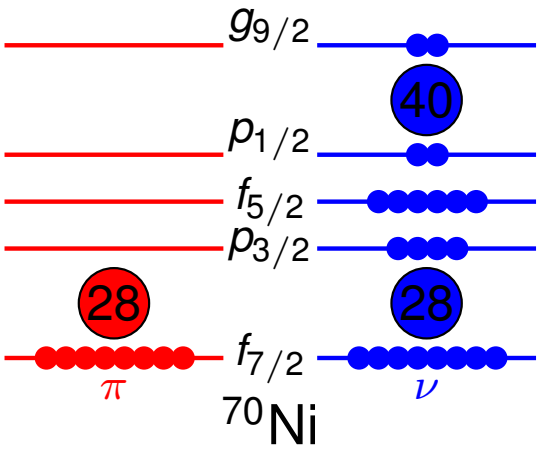

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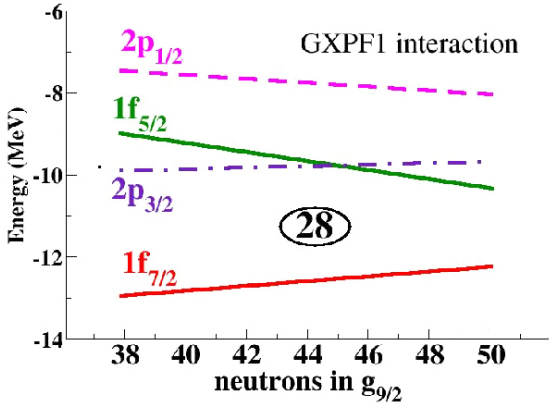

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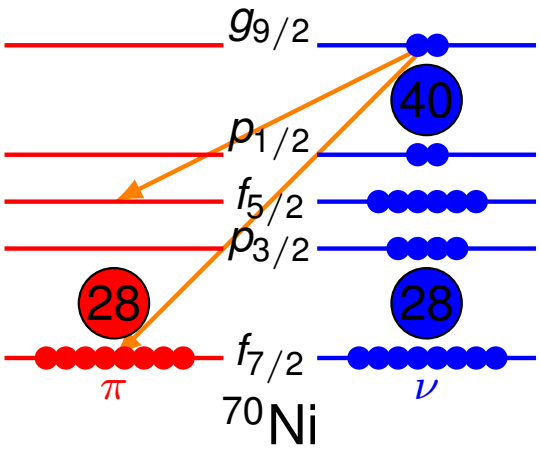

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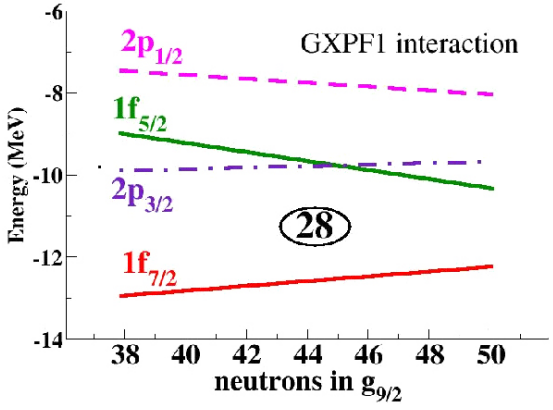

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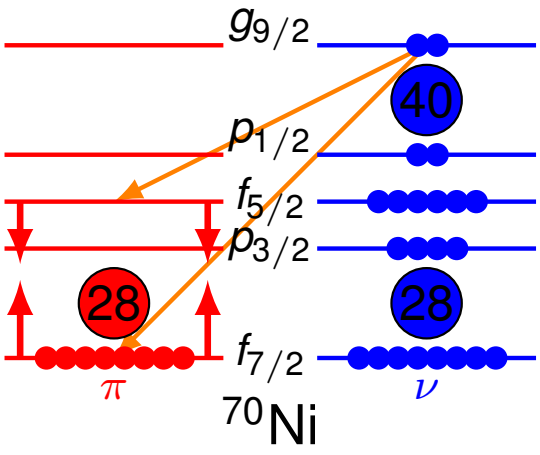

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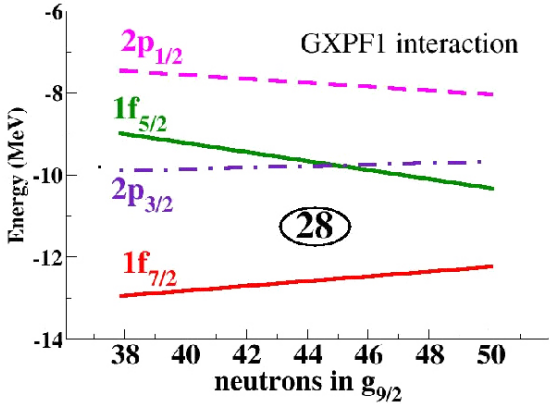

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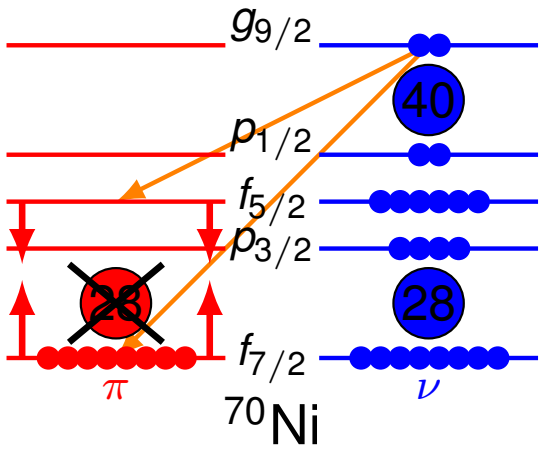

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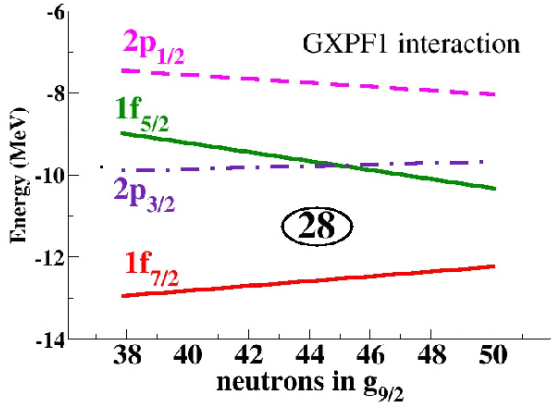

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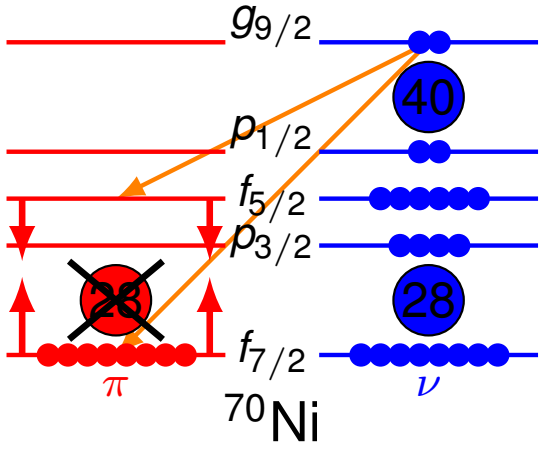

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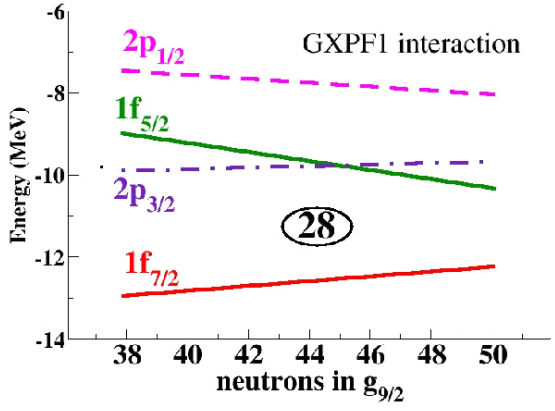

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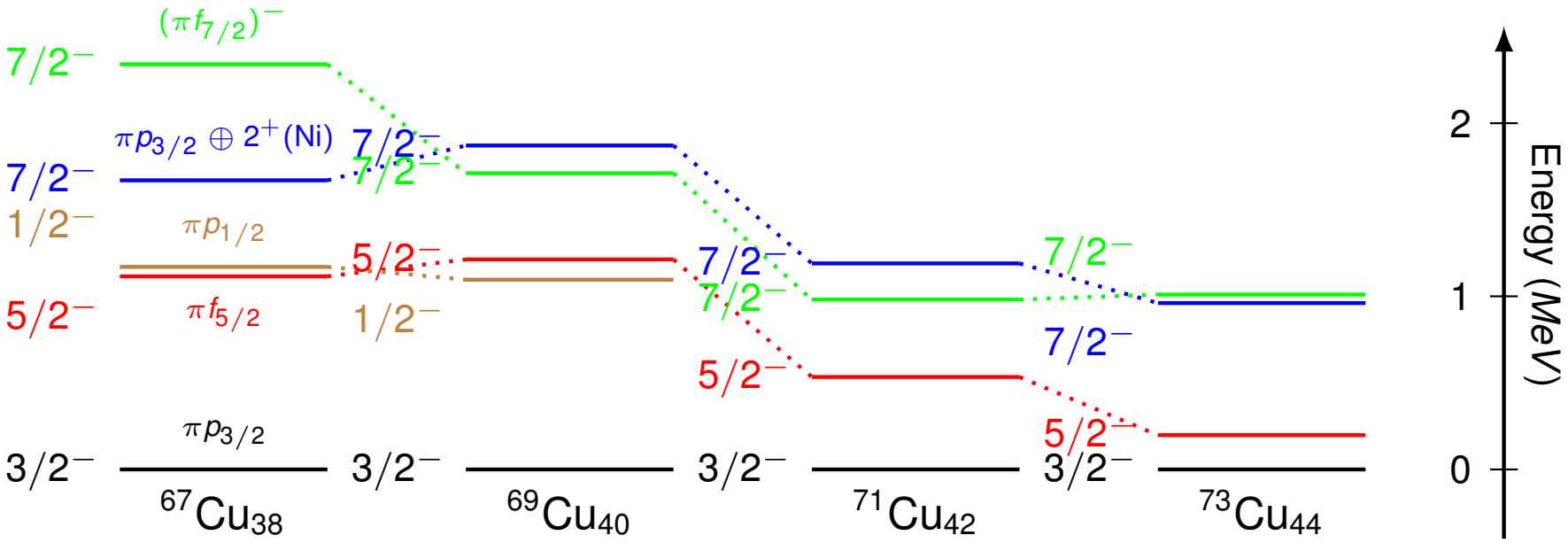
Odd-A Cu isotopes



Previously investigated by the means of:

- Transfer reactions (^{67,69}Cu) [Zeidman, 1978]
- Deep inelastic (^{71}Cu) [Grzywacz, 1998]
- β-decay (^{69,71,73}Cu) [Franchoo, 1998]

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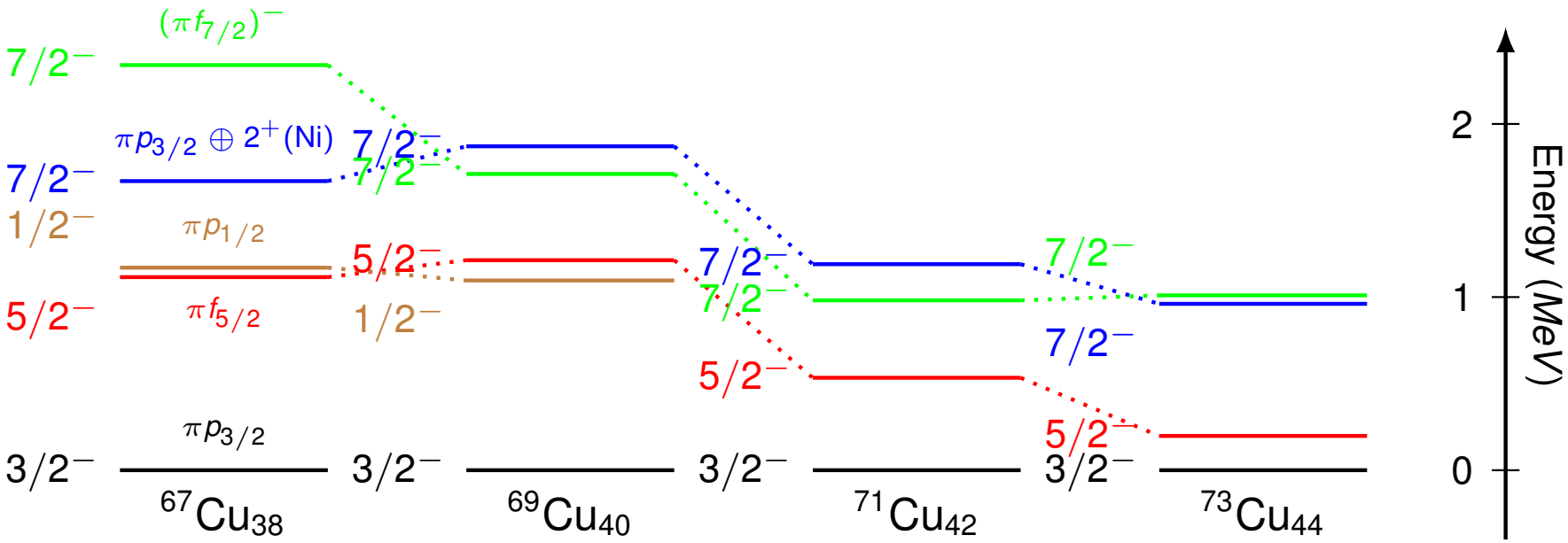


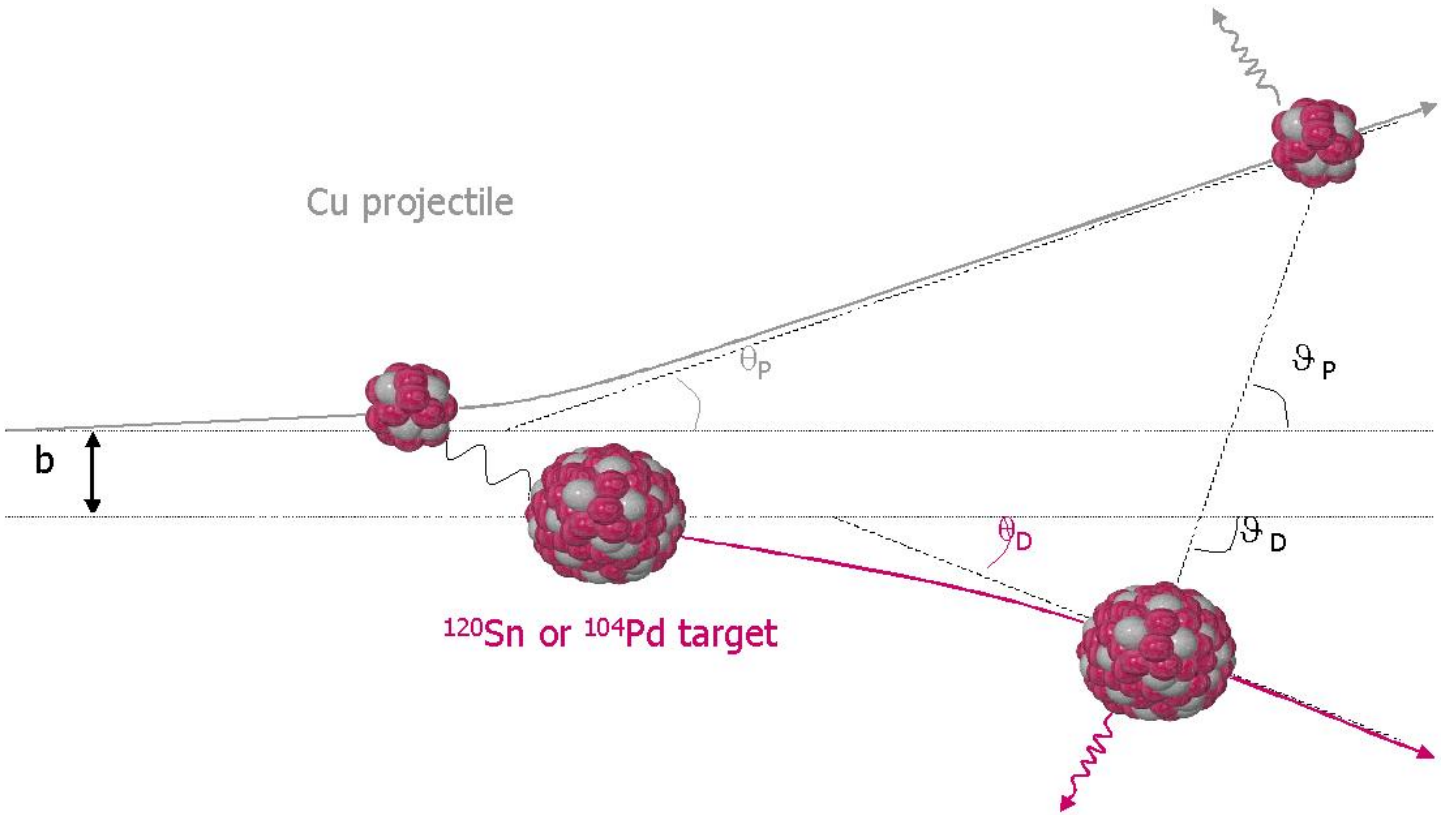
Our goal

Experimental determination of the $B(E2, I \rightarrow \frac{3}{2}^-_{gs})$-values for these low-lying levels (I)

$$B(E2, I_i \rightarrow I_f) = \frac{1}{2I_i + 1} |< \alpha_f, I_f \| \mathcal{O}(E2) \| \alpha_i, I_i >|^2$$

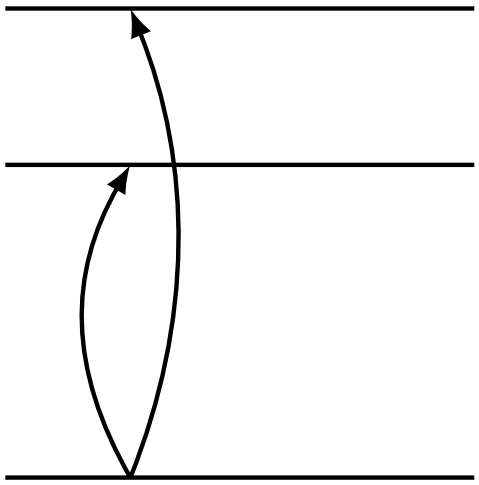
Outline

General description



$d\sigma_{E\lambda}$ depends on projectile energy and $B(E\lambda)$

Relative measurement



Method

σ_{coulex} can't be measured directly.
The γ-rays succeeding the Coulex can be observed. σ_{coulex} can be obtained from relative γ-intensities.

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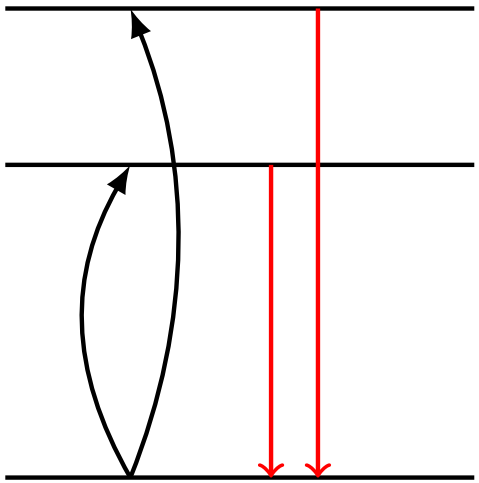
- σ_{target} can be calculated
- y is the target purity
- r is the beam purity

Relative measurement



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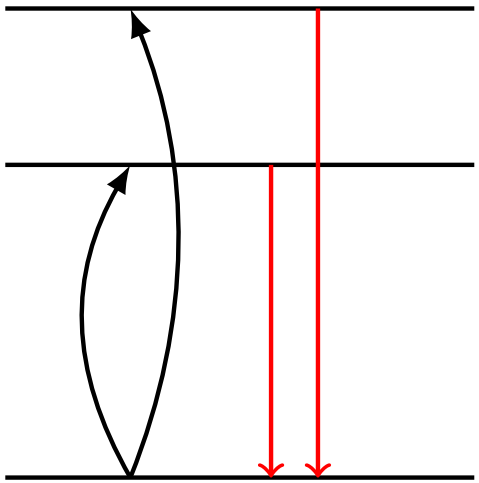

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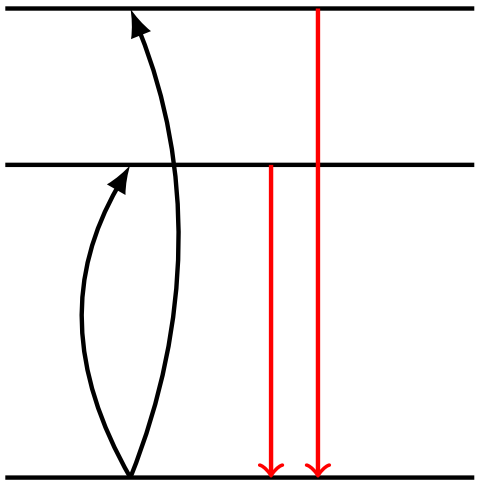

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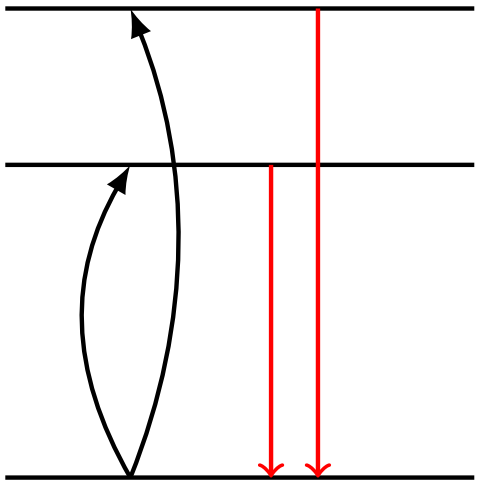

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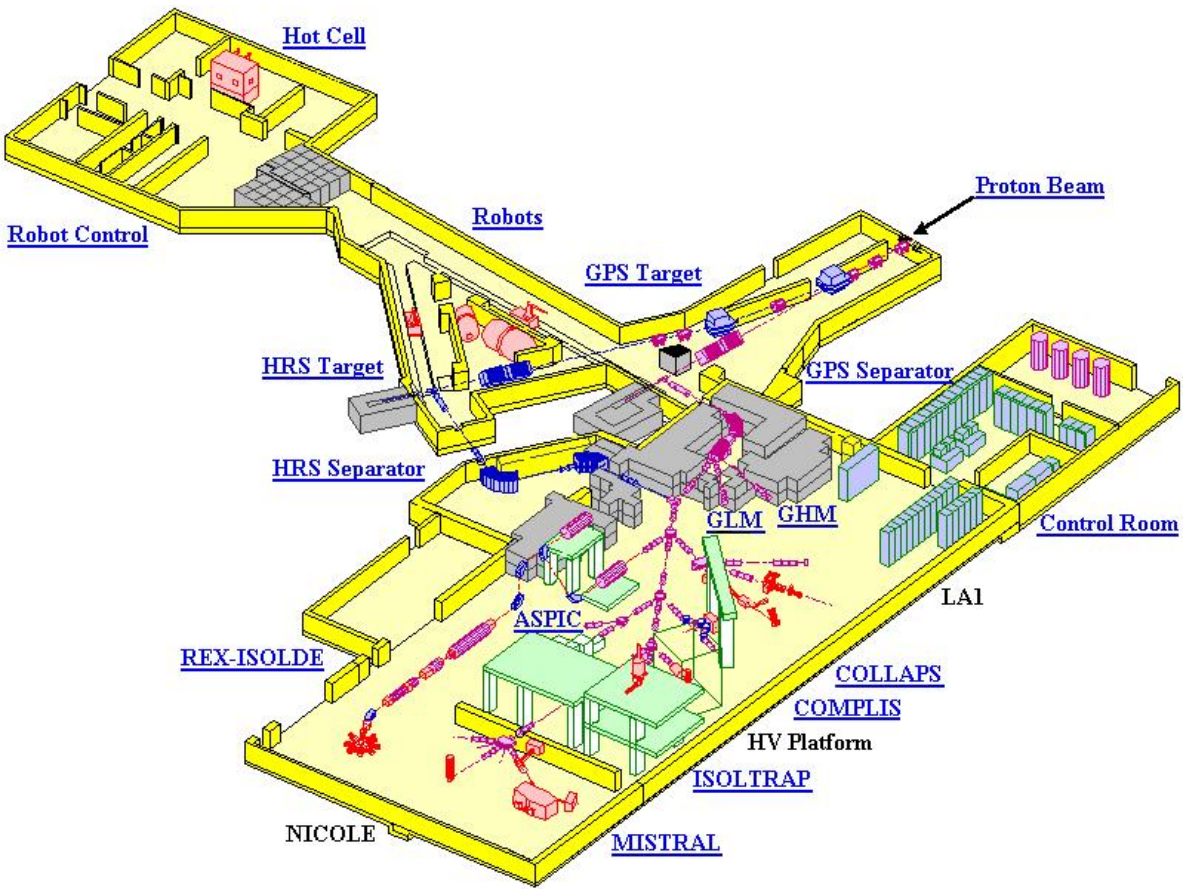
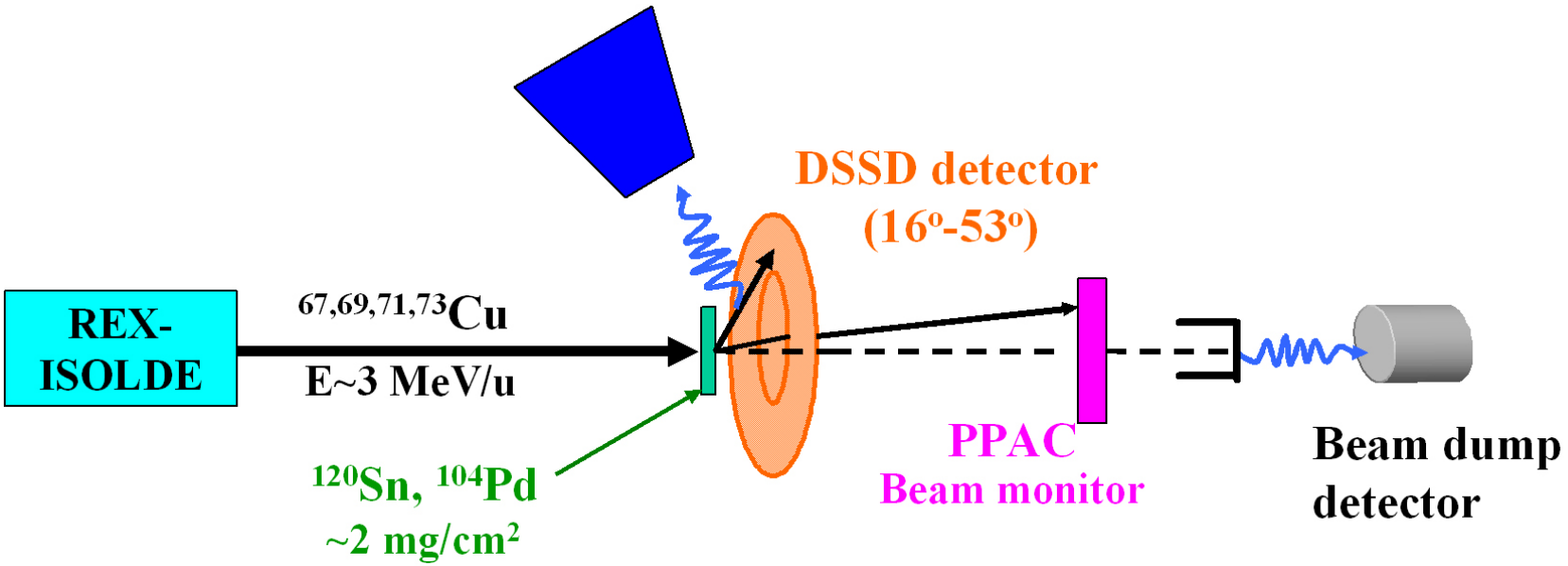
Outline

CERN-ISOLDE



1. 1.4 GeV Proton beam on UC_x-target
2. Laser ionisation by RILIS (Z-selection)
3. Isotope selection by GPS
4. Bunching and charge breeding in REX-TRAP and EBIS
5. Post-acceleration by LINAC
6. Arrival at MINIBALL Set-up

Experimental Set-Up

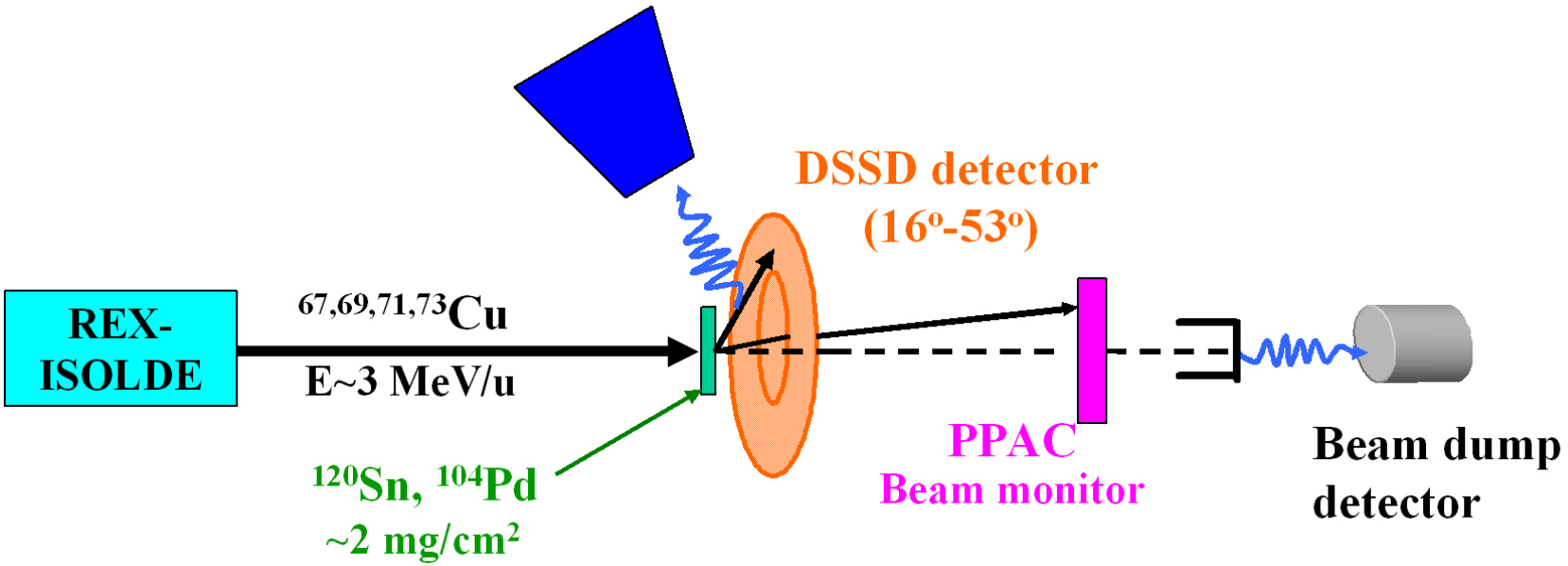


MINIBALL Clusters

- 8 clusters
- 3 HPGe crystals each
- 6 fold segmentation
- 8.5% efficiency at 1 MeV

DSSSD Particle detector

- **D**ouble **S**ided **S**egmented **S**ilicon **D**etector
- 4 segmented quadrants
- 12 annular strips (θ - front)
- 24 sector strips (φ - back)



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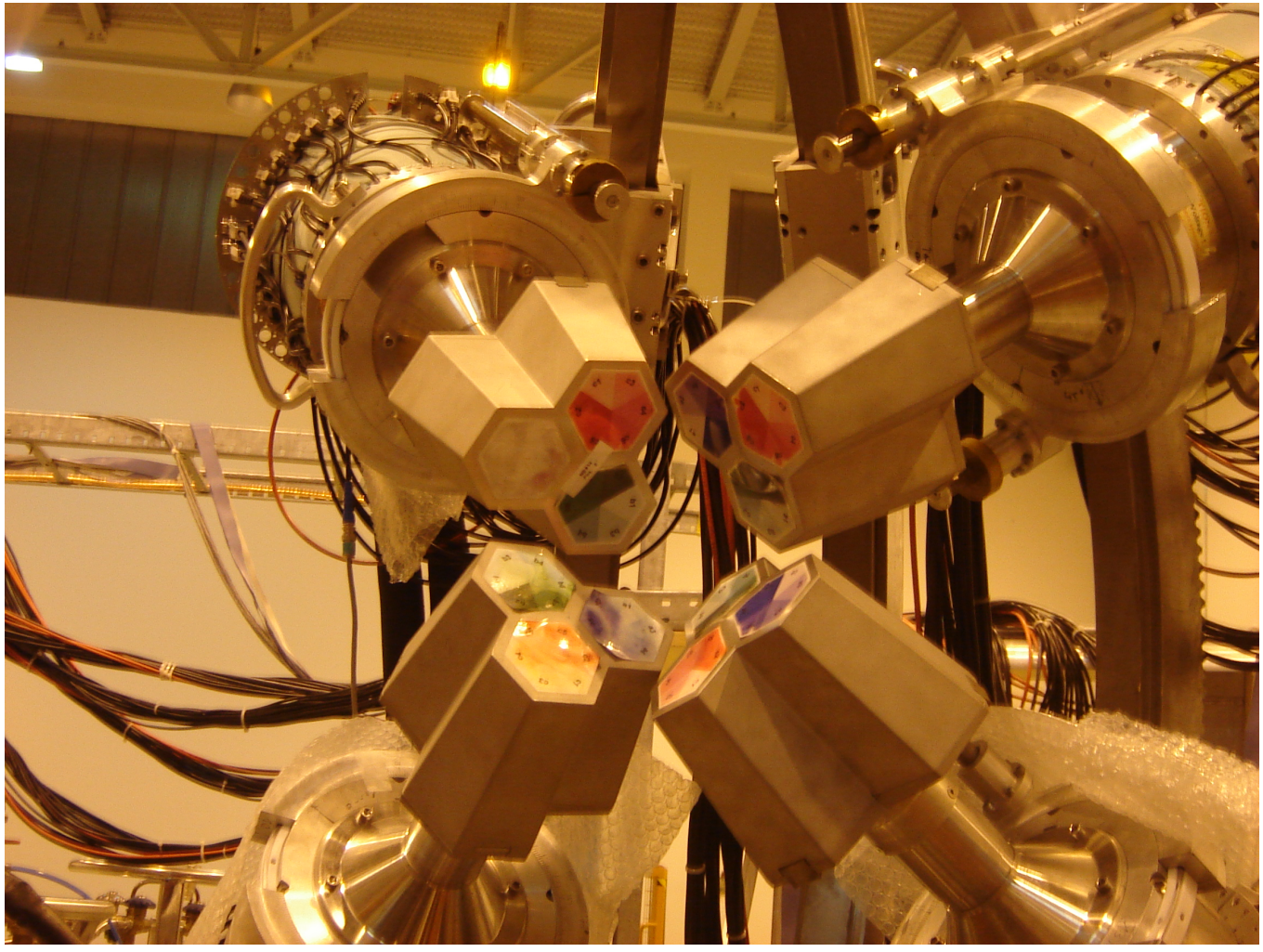

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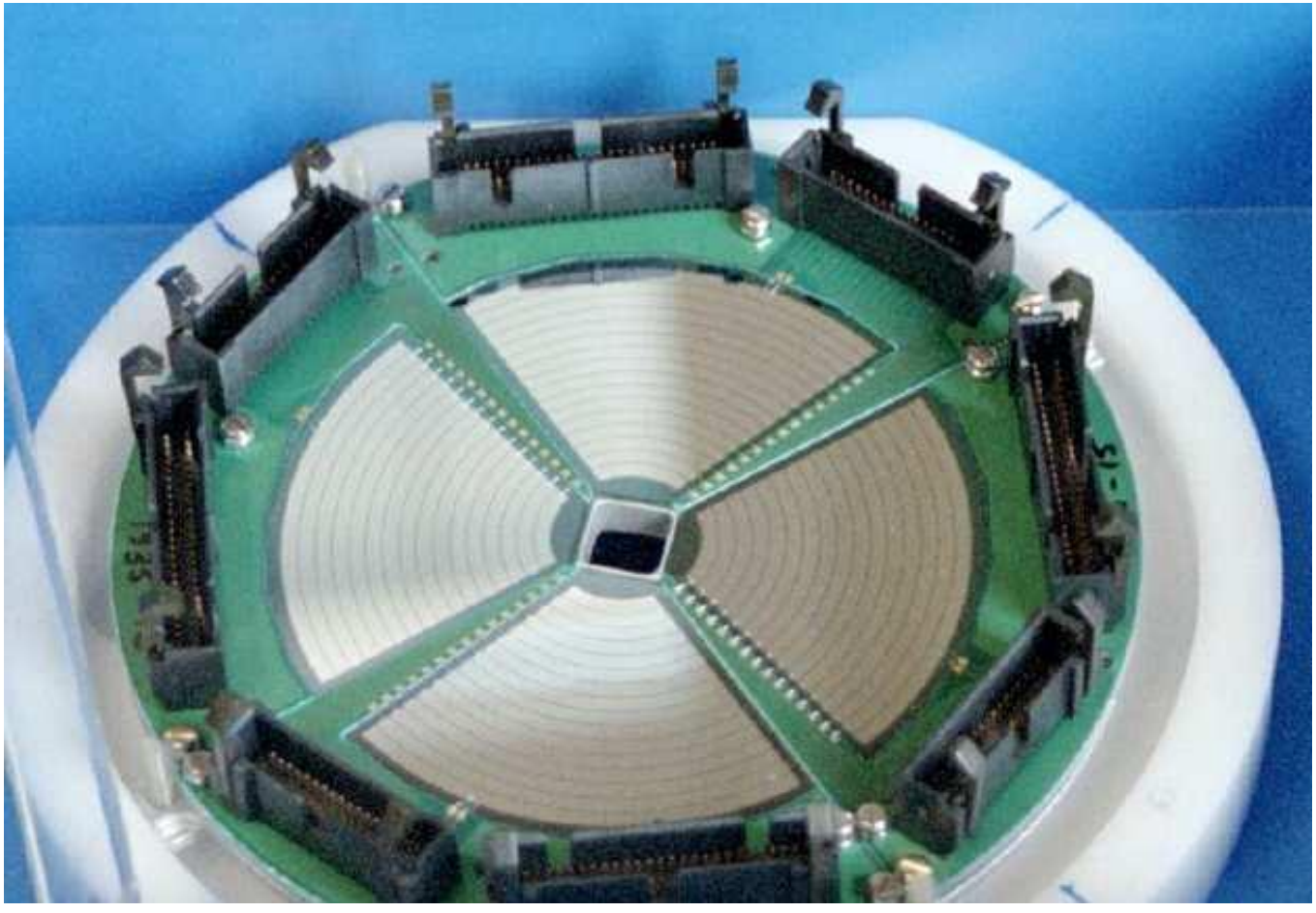

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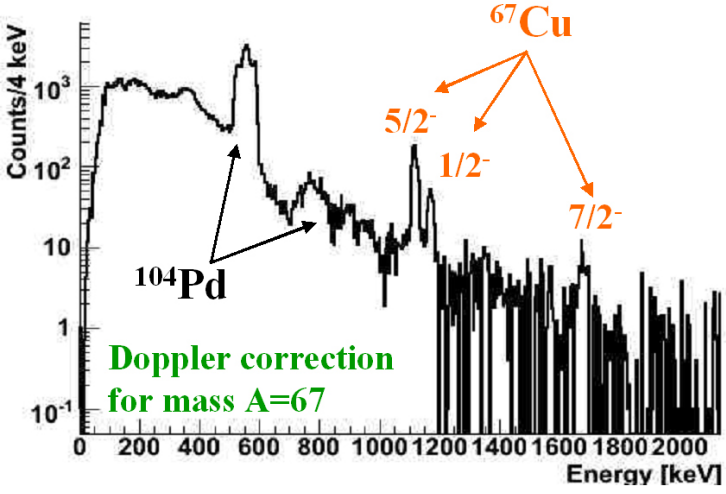
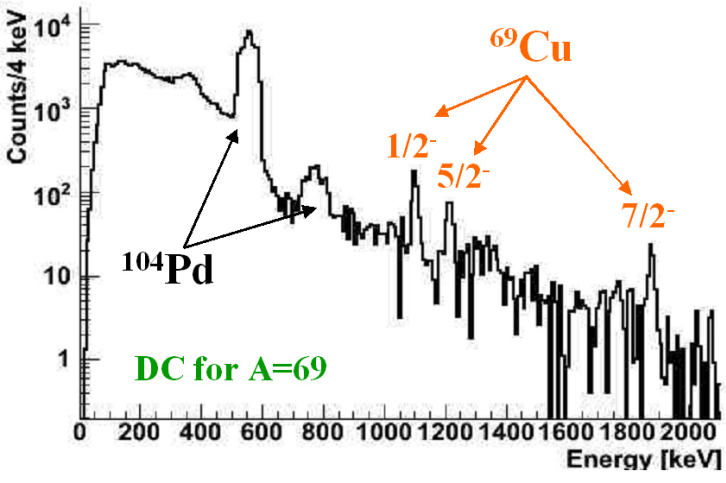
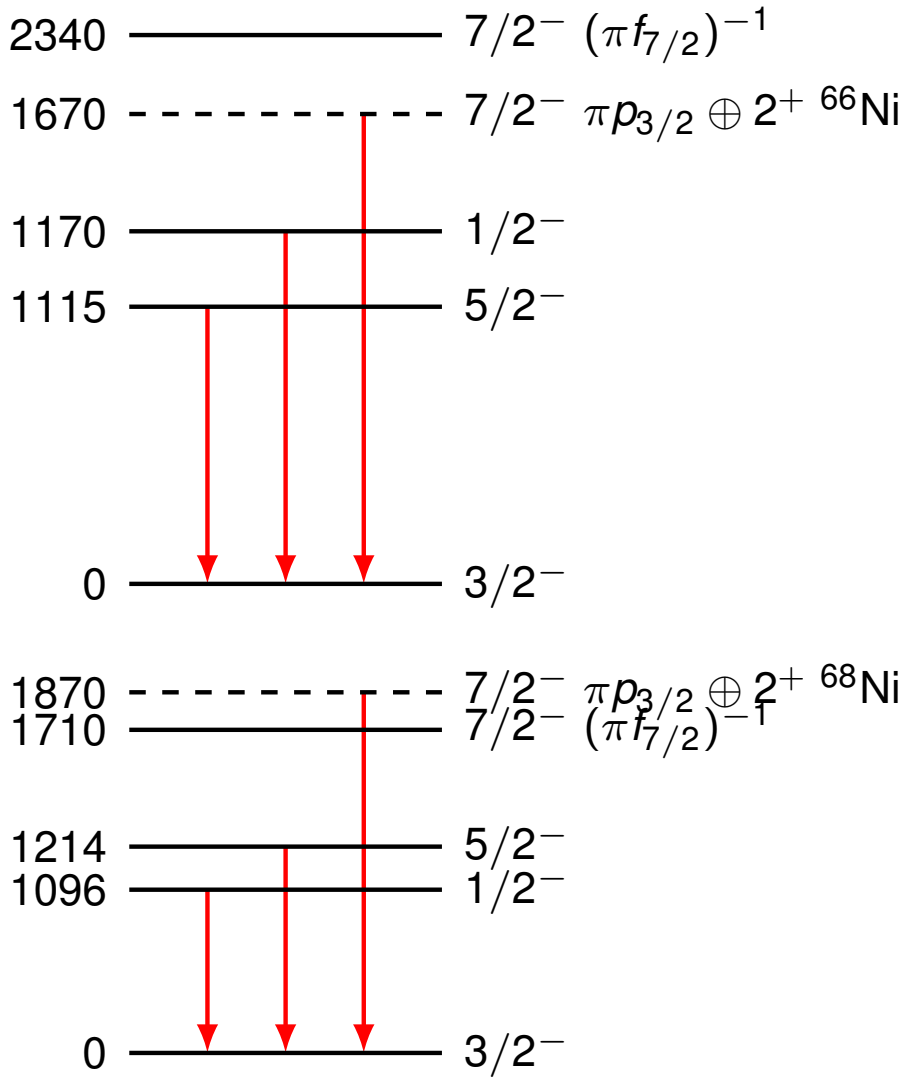
Experimental Spectra

^{67,69}Cu







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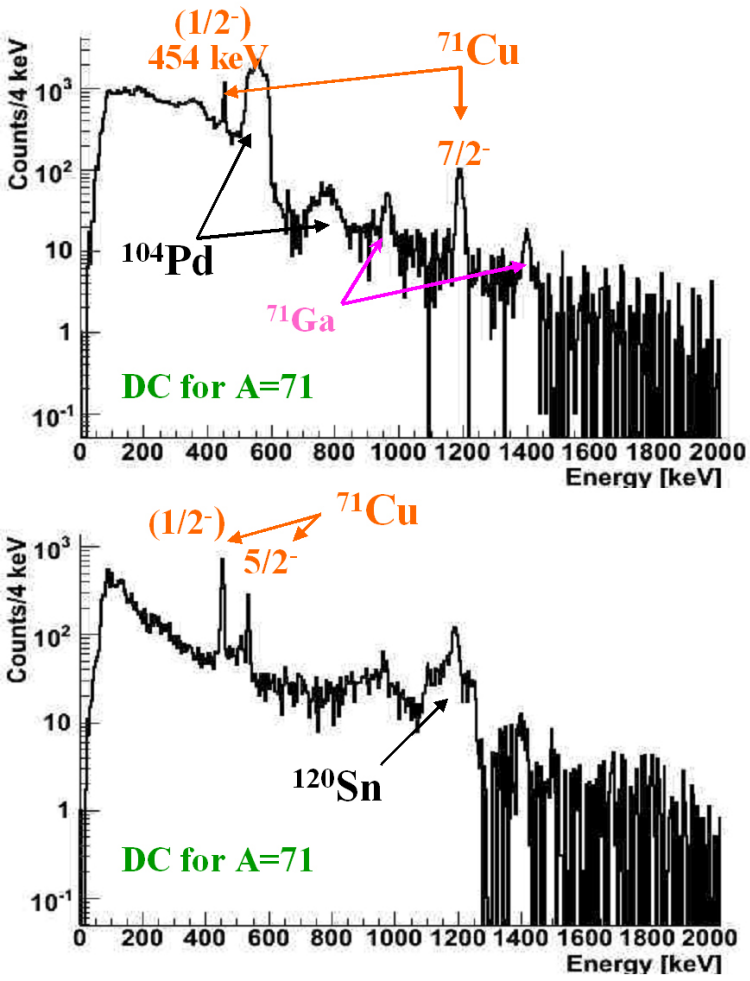

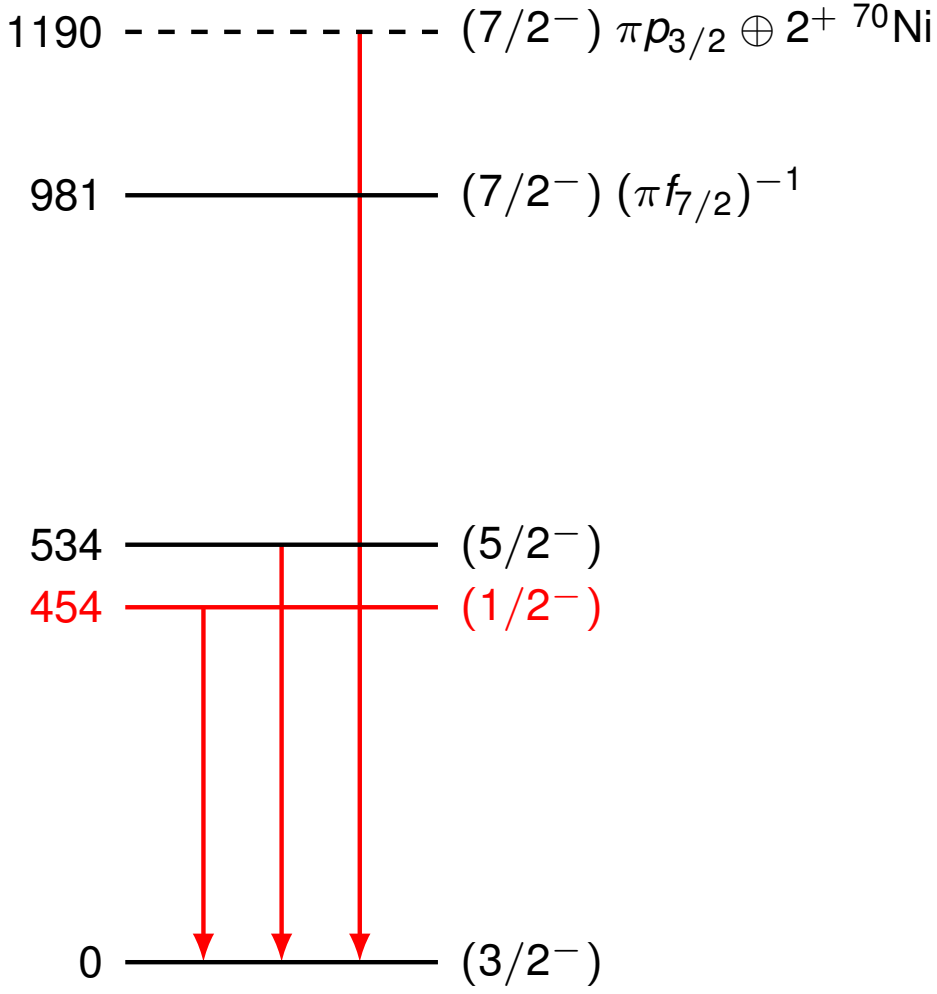

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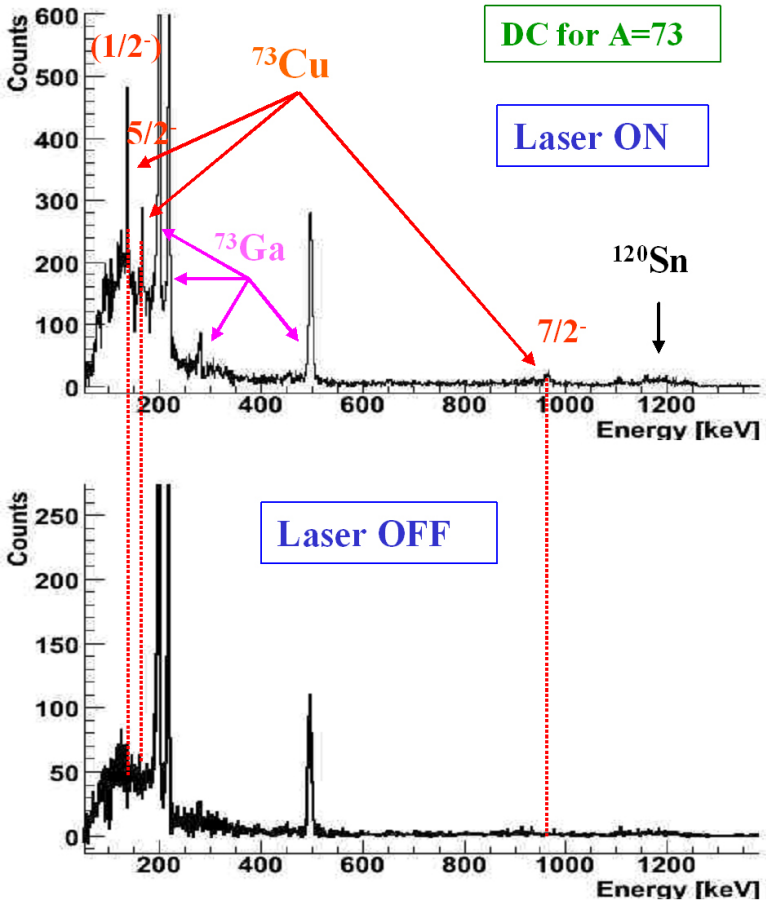

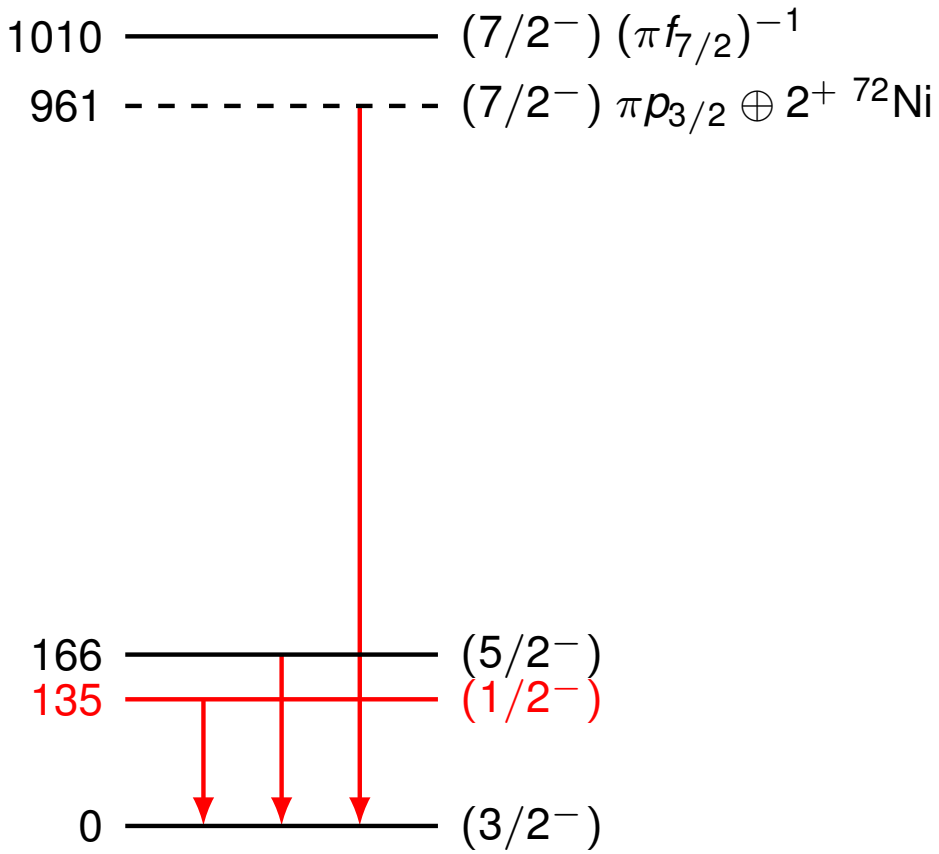

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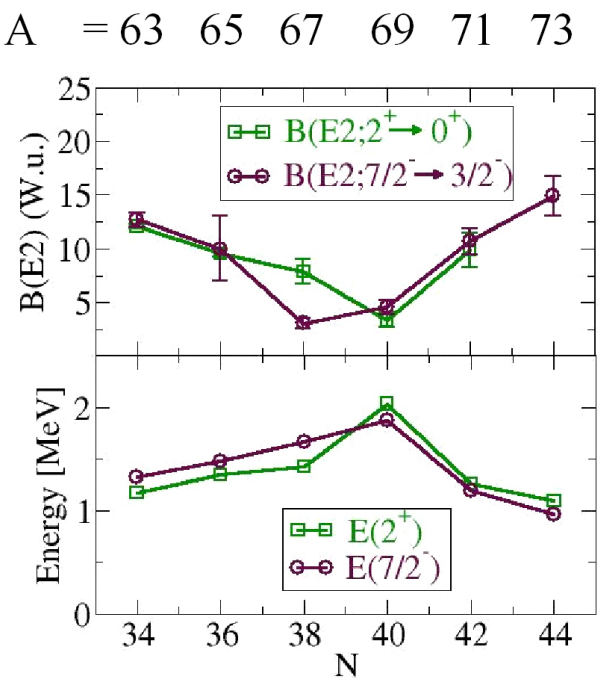

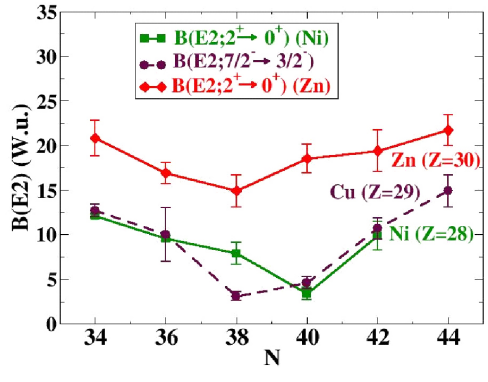

[Robinson, 1964]

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- $B(E2; 7/2^- \rightarrow 3/2^-)$: minimum collectivity at $N = 38$
- $B(E2; 7/2^- \rightarrow 3/2^-) \cong B(E2; 2^+ \rightarrow 0^+)$ in agreement with the proposed $p_{3/2} \oplus 2+$ nature for the $7/2^-$ states
- Trend in the odd-Cu isotopes similar to that shown by the even-even Zn isotopes
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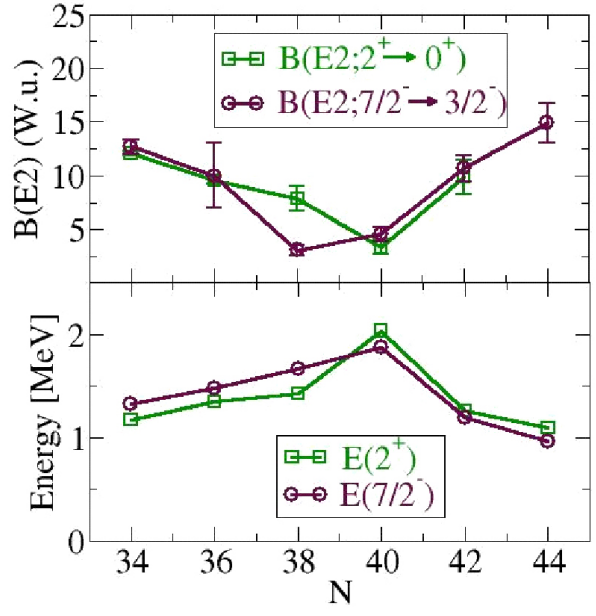
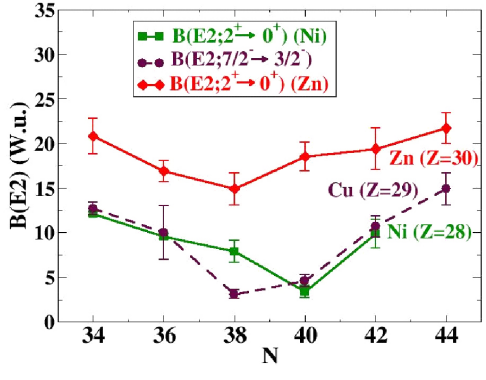
A = 63 65 67 69 71 73





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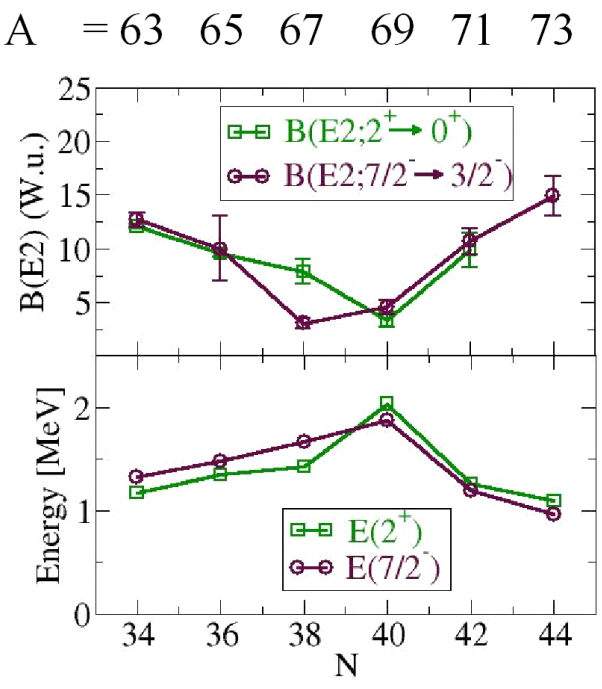

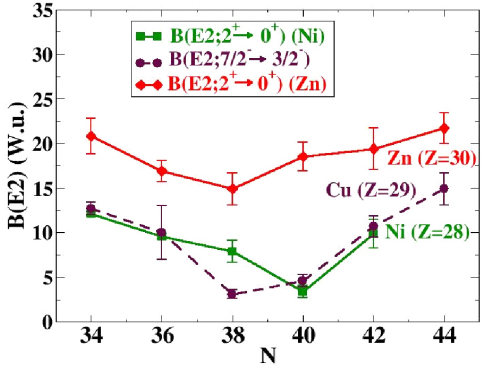

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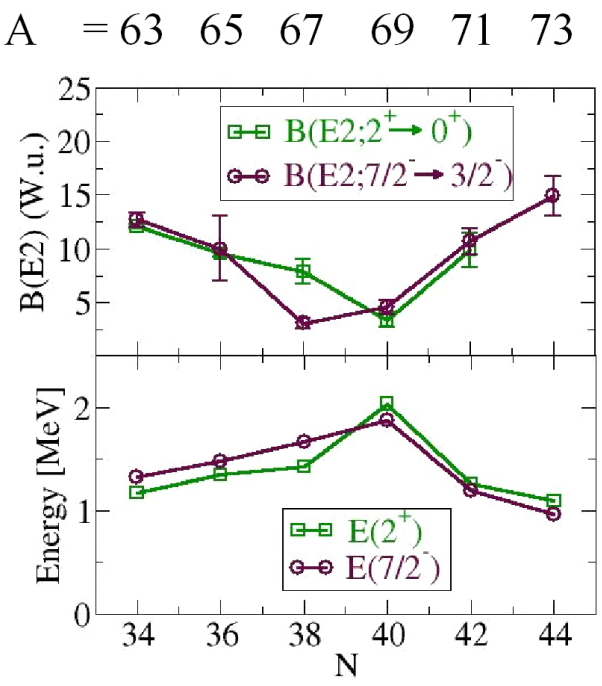

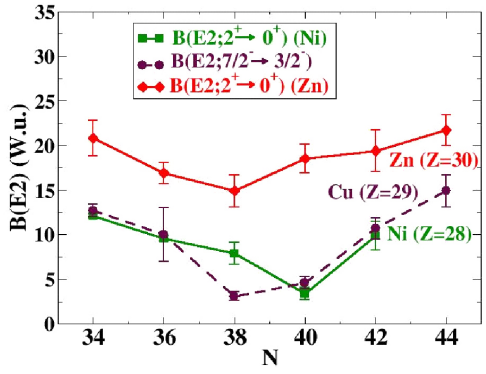

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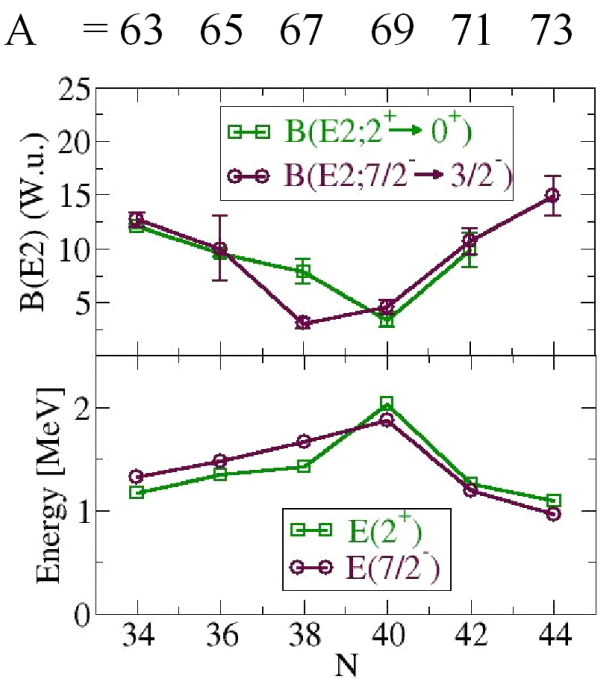

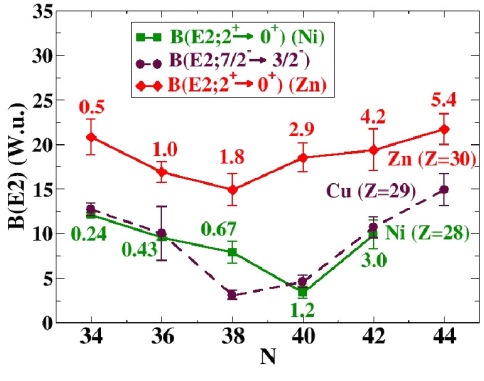

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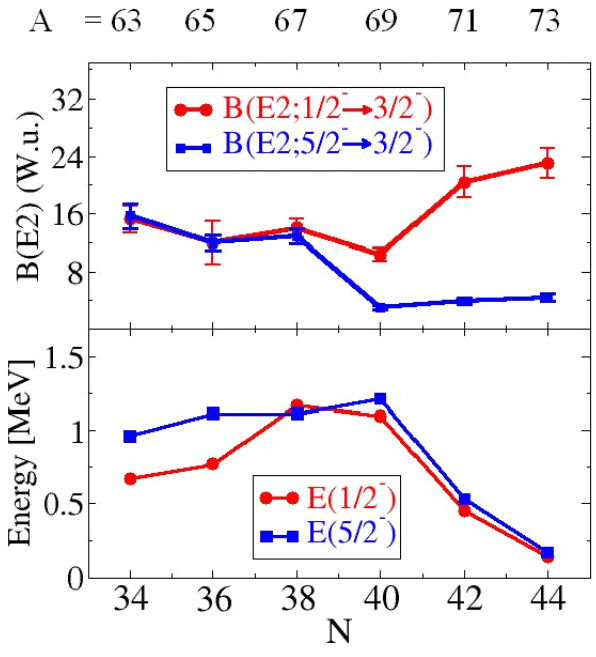

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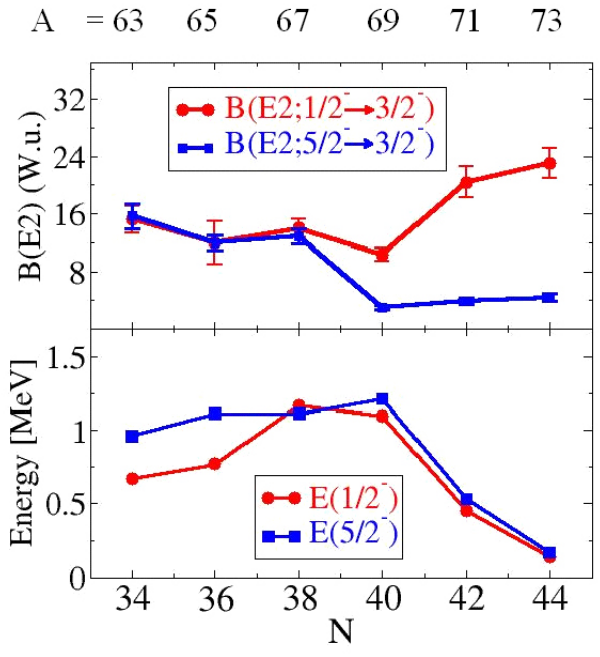

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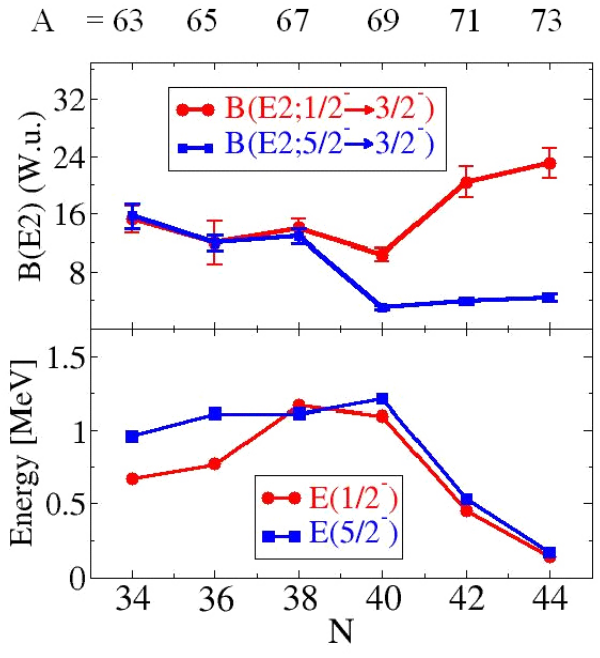

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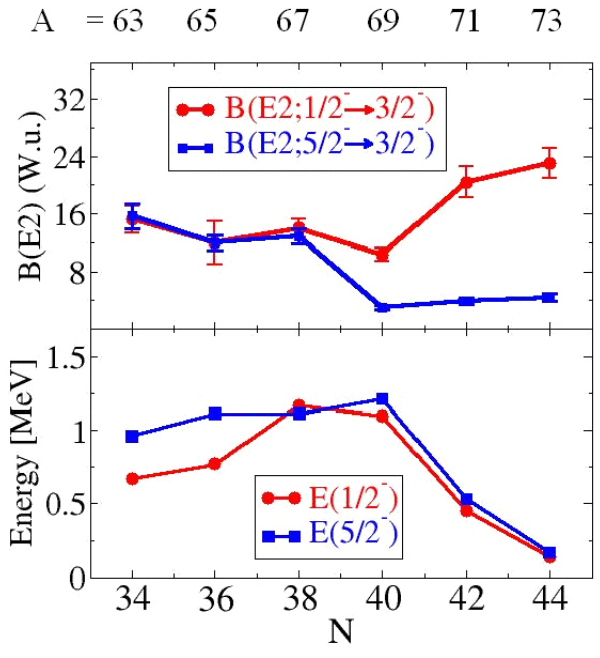

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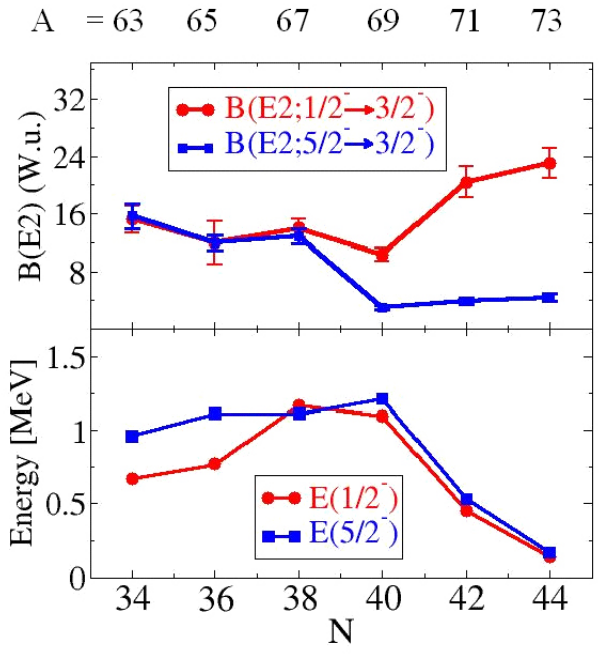

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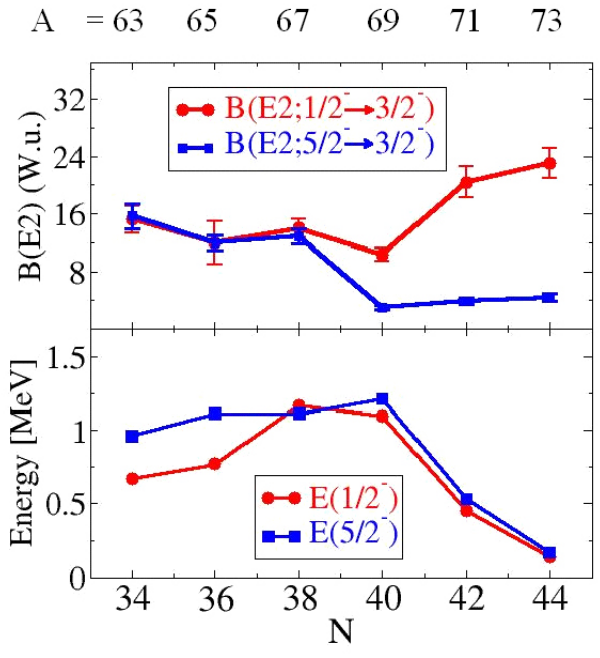

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- The $B(E2)$**-values** for the transitions depopulating the $1/2^-$, $5/2^-$ and core-coupled $7/2^-$ states in ^{67,69,71,73}Cu were measured.
- **Identification** of a new state (spin $1/2^-$ is proposed) in ^{71,73}Cu.
- **Existence of different types of configurations** at low excitation energies beyond $N = 40$, which is expected to influence the evolution of the shell structure towards ^{78}Ni.

- Outlook
  - Coulex of ^{75}Cu at REX-ISOLDE.
  - Transfer reactions at REX-ISOLDE (^{66}Ni(d, p)).
  - Coulex of Ga-contamination *(in progress)*.

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